Appendix C
Geotechnical Reports

THE MANITOBA WATER SERVICES BOARD

NEEPAWA HOG PROCESSING FACILITY

NEEPAWA, MANITOBA

GEOTECHNICAL INVESTIGATION

JUNE, 1986

PREPARED BY

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June 4, 1986

The Manitoba Water Services Board
Imperial Square
2022 Currie Blvd.
P. O. Box 1059
Brandon, Manitoba
R7A 6A3

Attention: Mr. Dick Menon, P.Eng.
Chief Engineer

Dear Sir:

Re: Neepawa Hog Processing Facility
Geotechnical Investigation

Attached is our report on site subsurface investigations, geotechnical design recommendations and clay liner borrow investigations relative to the waste disposal aspects of the above mentioned facility.

Should you have any questions on the contents of the report, or wish to discuss any aspect of the design recommendations, please contact the undersigned, or our Mr. R. Wittebolle, P Eng.

Yours truly,

UMA ENGINEERING LTD.

R. Hood, P.Eng.
Vice President & Manager
Manitoba & Northwestern Ontario

T. Wingrove, P.Eng.
Director
Earth Sciences Division

TW/dh

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1.0 INTRODUCTION

A field investigation was conducted at the site of a proposed sewage lagoon for a hog processing plant near Neepawa, Manitoba. The investigation was required to:

1) Evaluate the soil stratigraphy at the site,
2) Establish foundation design criteria,
3) Evaluate several lining designs,
4) Provide data for seepage analysis,
5) Establish dyke cross sections.

In addition, recommendations for dyke construction procedures are provided.

2.0 FIELD INVESTIGATION

The field investigation consisted of a subsurface drilling program, piezometer installation, and falling head permeability tests. The field program was carried out from February 25-27, 1986. Subsurface drilling was performed with a truck mounted auger rig using 12.7 cm solid stem and 20 cm hollow stem augers, as required. General site supervision and borehole logging were provided by Mr. R. Schmidtke, E.I.T. of UMA Engineering Ltd. The locations of the 22 test holes are shown on Drawing 01. The holes were visually logged to identify soil types and representative samples were obtained for further laboratory analysis. Standard penetration tests were conducted at regular intervals to establish the relative density of the cohesionless soils. Undisturbed shelby tube samples were recovered from the fine grained soils.

To establish water levels at the site, standpipe piezometers were installed in Test Holes 7, 8 and 9, at depths of 7.39, 7.90 and 7.16 metres respectively. The piezometers were constructed of 50 mm diameter schedule 40 PVC tubing with the bottom 0.9 m section slotted and wrapped with filter cloth. The elevation of each piezometer was surveyed according to a bench mark elevation of 64[illegible]5 m established at the intersection of Station 4+50 and grid line No. 540.

Falling head permeability tests were conducted to determine the insitu permeabilities at the three piezometer locations. The data was analyzed using the Hvorslev method. The calculated permeabilities are shown on the test hole logs.

3.0 LABORATORY TESTING

Laboratory testing for dyke design and foundation analysis included gradation analysis, constant head permeabilities, and minimum and maximum density determination. The results of the laboratory testing are presented on the borehole logs in Appendix A or separately in Appendix B.

Laboratory testing for the clay liner investigation is discussed and included in Appendix C.

4.0 SITE AND SUBSURFACE CONDITIONS

4.1 Site Description

The proposed sewage lagoon site is shown on Drawing 01. A 3 metre deep borrow pit is located between the existing plant site and the proposed lagoon area. The lagoon site is a flat plain flanked on the east and west boundaries by topographical depressions. The ground surface slopes down to the north, at a grade of approximately 1%.

4.2 Subsurface Conditions

4.2.1 Soil Stratigraphy

The following major stratigraphic units were encountered during the field investigation:

1) Topsoil
2) Brown Sand
3) Grey Sand

These units are discussed separately below.

The black topsoil is generally silty and organic. The thickness of the topsoil layer is 0.3 metres.

A fine to medium, brown sand with subangular particles underlies the topsoil. The sand is medium dense with an average standard penetration count of 15 blows per 0.3 m. Gradation analysis shows that the sand has a fines content (passing #200 sieve) of approximately 5 to 10%. The sand is moist at the surface and generally becomes wet at a depth of 3.0 to 4.0 metres below existing ground surface. The brown sand extends on average to a depth of 6 metres below the ground surface.

Two laboratory constant head permeability tests established an average permeability of 5×10^{-3} cm/sec for the brown sand. The brown sand has a minimum and maximum dry density (ASTM D 2049) of 13.44 KN/m^3 and 17.04 KN/m^3, respectively.

Underlying the brown sand is a wet fine grey silty sand. The fine sand grades to a sandy silt with increasing depth. An average standard penetration blow count of 25 blows per 0.3 metres indicates that the sand is medium dense

Falling head tests completed in standpipes installed in test holes 7, 8 and 9 indicate an average permeability of 1.5×10^{-4} cm/sec for the grey sand. A constant head test in the laboratory produced a similar permeability value of 3.4×10^{-4} cm/sec.

4.2.2 Groundwater Conditions

Groundwater levels were recorded in the piezometers installed in Test Holes 7, 8 and 9. The groundwater elevations are shown on the borehole logs in Appendix A. Based on these three water level readings the water table slopes to the north with a horizontal gradient of 0.01 During the winter field program, the depth to the water table varied from 3 to 4 metres. The position of the water table will vary seasonally and annually and it is recommended that water levels be monitored to establish this range. Levels in the piezometers should be read twice monthly through April, May and June to establish the minimum depth to water table during the spring recharge period.

4.3 Seepage Analysis

Using the standard D'Arcy's Law analysis, the total seepage from the lagoon system was calculated using the following parameters:

$$Q = \frac{kha}{l} \quad (4.1)$$

k = permeability of the clay liner = 1×10^{-9} m/sec

Δh = depth of retained water plus liner thickness = 6 metres

l = thickness of clay liner = 1 metre

a = area of lagoon = 28,523 square metres

Therefore $Q = 1.71 \times 10^{-4}$ m^3/sec or $1.2 \times 10^{+6}$ UK gal/year

To determine if the seepage would occur as unsaturated or saturated flow below the liner, the following equation was used:

$$\frac{Ks}{KL} > \frac{Dww + l - hd}{L} \quad \text{for unsaturated flow} \quad (4.2)$$

Where Ks = hydraulic conductivity of the subsoil = 5×10^{-5} m/sec

KL = hydraulic conductivity of the liner = 1×10^{-9} m/sec

Dww = depth of wastewater in pond = 5 metres

L = liner thickness = 1 metre

hd = air entry pressure at saturation = -0.5

Using equation 4.2 it is obvious that unsaturated flow will occur.

The time required for the seepage front to reach the saturated zone after pond filling was calculated using the following equation:

$$t = \frac{Sr\,(Dw - hf)}{V} \quad (4.3)$$

Where: t = time after first filling

Dw = depth of groundwater table below the bottom of the pond liner (m) = 1 metre

hf = the height of the saturated portion of the capillary fringe above the groundwater table = 0.5

Sr = specific retention of the soil = 0.15

V = seepage rate through liner = 6×10^{-9} m/sec

Using equation 4.3, the time for the seepage front to reach the groundwater table is approximately half a year. Since the groundwater levels are expected to fluctuate seasonally, the calculated time probably over-estimates the actual time of first arrival.

5.0 FOUNDATION DESIGN RECOMMENDATIONS

It is understood that a pumphouse will be located between the existing plant site and the sewage lagoon. Footings founded on undisturbed sand at a minimum depth of 2 metres below grade may be designed with an allowable net bearing capacity of 190 kPa (4000 psf). A minimum footing width of 0.6 metres is recommended.

The brown sand contains occasional silty lenses that are considered to be frost susceptible. If the pumphouse is not heated, insulated footings will be required to retard the advancement of the frost front below the footing.

The major design consideration for deep foundations is the location of the water table. Installations founded at a depth of greater than 3 metres will require shoring of the cohesionless sands. Careful construction control will have to be exercised to prevent piping at the bottom of the excavation. Dewatering should also be considered as an alternative construction method.

6.0 PROPOSED LAGOON CROSS SECTION

The depth of the lagoons is restricted by the depth to the water table. The water table is presently 3.0 to 3.5 metres below the ground surface and the level could rise an additional 1.0 metre during seasonal fluctuations. Therefore, the bottom of the lagoons should be founded at a depth that will allow lagoon excavation during a period of high water level.

The pond dykes should be well constructed to avoid settlement, slumping, and erosion. Two interior dyke slopes were used for the lagoons. The small lagoons have interior dyke slopes of 3H:1V. Slopes of this grade were considered to be acceptable for the following reasons:

1) The water level would only experience minor fluctuations (<0.5 m) during operation.

2) The dykes will be composed of well compacted granular material.

3) The dykes will be well protected against erosion with granular riprap.

The large lagoon will experience relatively large fluctuations in water level (± 2 metres) and significant waves can be expected to develop due to the large surface area. For these reasons, the interior slopes of the large lagoon are at a grade of 4H:1V.

All interior slopes should be protected from erosion with a minimum of 30 cm of granular riprap. The riprap should extend from 0.6 metres below the minimum water level to 1 metre above the maximum water level. It is recommended that the riprap be underlain by a geotextile filter cloth to prevent the underlying impervious liner from being washed out through the coarse riprap. The riprap should be composed of durable rock typically 75 mm to 150 mm in size.

The exterior slopes should be 4H:1V to allow for maintenance and covered with 10-20 cm of seeded topsoil. The dyke crest should be about 3 metres wide to allow vehicle access and topped with 10-15 cm of compacted gravel as a trafficable surface. The dyke crest should have a slight camber to promote runoff.

The dykes should be constructed using the following construction guidelines:

1) Foundation preparation should consist of stripping topsoil and any soft compressible or otherwise unsuitable materials from the dyke area.

2) The dyke fill should consist of the brown surficial sand and should be free of organics, organic soil, debris, cobbles over 15 cm diameter, snow, ice, or soft compressible materials.

3) The granular dyke fill should be compacted to 95% of Standard Proctor dry density using a vibratory smooth drum roller

4) Compaction control should be provided on a regular basis during fill placement.

It is recommended that a drain be installed near the exterior toe of the sand embankment. The purpose of the drain is twofold:

1) To reduce the porewater pressures in the downstream portion of the dam and hence to increase the stability of the downstream slope against sliding.

2) To control any seepage water as it exits at the exterior slope in such a way that water does not carry away particles of the embankment soil.

The drain should be constructed to meet the filter requirements of the embankment material.

7.0 LINING DESIGNS

The sewage lagoon is founded in permeable sands and thus will require a low permeability liner to control seepage. Three types of liners were considered for this study:

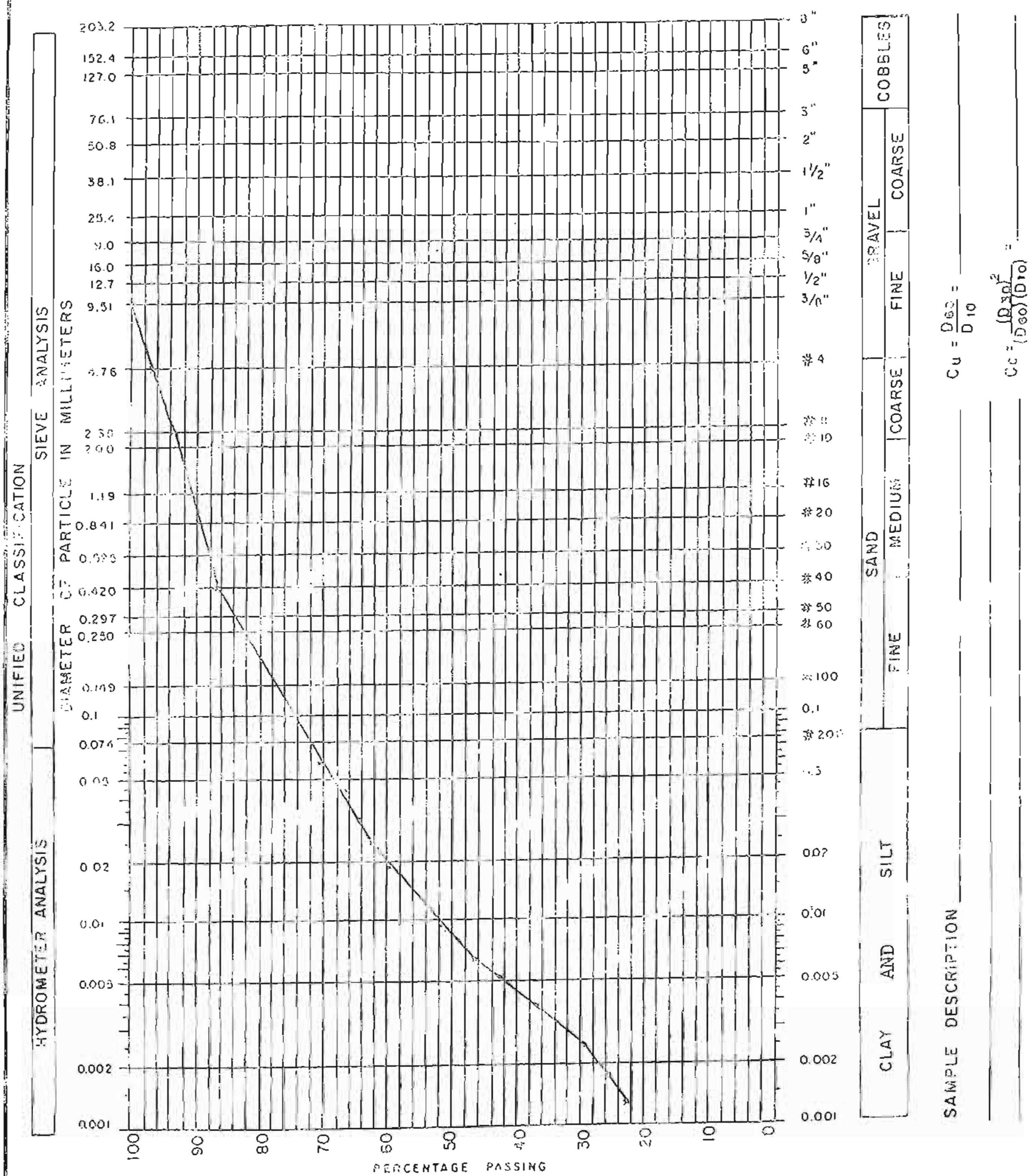
1) Soil bentonite admixture
2) High density polyethylene geomembrane
3) Compacted clay liner

7.1 Soil Bentonite Admix Liner

Powdered or granular bentonite can be mixed with the brown sand to form a low permeability liner. The successful performance of a bentonite admix liner is highly dependent on the degree of quality control provided during construction. A representative sample of the brown sand was sent to the American Colloid Company to determine the recommended bentonite application rate. The analysis indicated that SG-40 grade bentonite should be applied at a minimum rate of 30 kg per square metre as a 15 cm thick mixed blanket. The bentonite sand layer should be compacted at optimum moisture to a minimum of 90% of Standard Proctor dry density to attain a permeability of 1×10^{-8} cm/sec. To compensate for mechanical imperfections in placement of material and minor variations in the soil characteristics, a recommended application rate of 38.2 kg/m^2 should be employed. American Colloid Company recommends that Saline Seal 100 bentonite be used for this project.

In general, bentonite admix liners are more susceptible than compacted clay to erosion and mechanical damage and thus should be protected by a soil cover. A minimum depth of wastewater should be maintained in the pond at all times to prevent drying of the bentonite on the pond bottom and to protect against frost heave.

GRADATION ANALYSIS



UMA Engineering Ltd
Engineers & Planners

1479 Buffalo Place, Winnipeg, Manitoba, Canada

JOB NO: 0326-049-01	DATE: MAY 23, 1986
PROJECT: NEEPAWA HOG PROCESSING PLANT	
SITE: B	
LOCATION: SEE DETAILED SITE INVESTIGATION C-2	
HOLE NO.: 8	SAMPLE NO.:
DEPTH: .8 m	TECHNICIAN: T.H.

7.2 Geomembrane Liner

A geomembrane liner must have a very low permeability to water transmission and must be strong enough to resist damage during installation and the service life of the liner. For the sewage lagoon an 80 mil High Density Polyethylene liner would be required. High density polyethylene is tough and resistant to damage. It has good resistance to ultra violet radiation and is resistant to a wide variety of chemicals. Seaming is done by heat welding, which requires good control of temperature, and moisture conditions. High density polyethylene is very thermo plastic and considerable shrinkage and swelling can occur from day to night. If seaming is carried out in warm weather, then sufficient slack must be left in the sheets to avoid high stresses in the liner seam. On the other hand, too much slack may result in problems with wrinkles during seaming. In some cases seaming at night may be required.

The installation of a liner requires a high degree of construction control to ensure adequate performance. Due to the thinness of the liner, it is susceptible to tearing caused by vehicle traffic, mechanical lagoon cleaning, and ice forces. If a geomembrane liner is used, the interior side slopes should be flattened to 3.5 H:1V to prevent slippage of the liner and to minimize ice forces.

7.3 Compacted Clay Liner

If a clay borrow source is available a compacted clay liner should be considered for this project. The clay content of the liner material should be 25% or greater. Laboratory hydraulic conductivity tests on the proposed clay will be required to assess the suitability of the soil as a liner material. It is recommended that the liner design be based on a lab permeability that is one order of magnitude higher than the average laboratory permeability value. If the permeability of the in-place liner must be 1 x 10^{-9} m/s, the lab permeability should be no greater than 1 x 10^{-10} m/s.

The subgrade surface below the compacted clay liner should be relatively level and proof rolled to provide a good base for compacting the first liner lift. The clay should be compacted in 15 cm maximum loose thickness to a minimum of 95% of Standard Proctor dry density to a minimum thickness of 1 metre. The water content should be between 2% and 5% wet of optimum moisture content. Each lift should be compacted within the specified water content range to the required density using sheepsfoot compaction. Insitu density and moisture content tests should be carried out on a routine basis for each lift. The compacted liner should be smoothed out with a smooth roller compactor to reduce the liner surface area exposed to water absorption and swelling. Ideally the liner should be flooded as soon as possible after construction and acceptance.

When the pond is emptied the liner should not be allowed to dessicate. Also long rooted grasses and weed growth may create root holes in the liner and also cause drying of the soil. Burrowing animals can create seepage paths through dykes and should be controlled.

Subsequent to the site subsurface investigation, a borrow study was completed to identify potential clay sources for lining the ponds. That work is described in Appendix C of this report.

7.4 Discussion on Liner Options

At present the preferred liner system is compacted clay. The thickness of a compacted clay liner (1 metre) makes it less prone to rupture from ice forces or mechanical cleaning. Also, no specialized construction techniques are required for the installation of a clay liner. Provided that a suitable clay source can be found, we recommend that a compacted clay liner of one metre thickness be used for a low permeability barrier.

Respectfully submitted,
UMA ENGINEERING LTD.

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Director
Earth Sciences Division

R. J. Wittebolle, M.Sc., P.Eng.
Geotechnical Projects Coordinator
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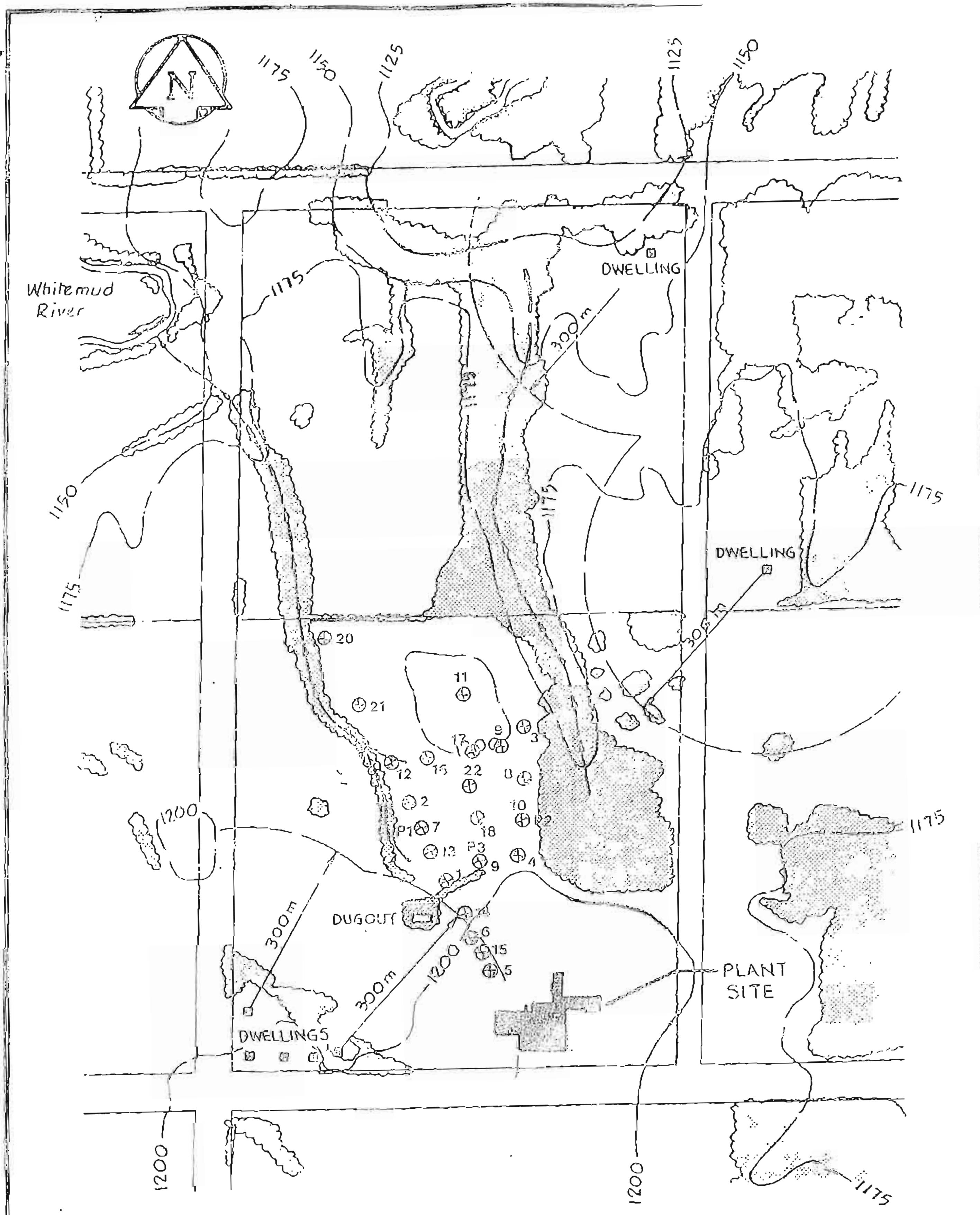

NOT TO SCALE

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MANITOBA WATER SERVICES BOARD

TITLE. TEST HOLE LOCATIONS	
JOB No. 0326-049-01-07	DATE: MARCH 1986
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APPENDIX A

TEST HOLE LOGS

UMA Engineering Ltd.
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PROJECT NEEPAWA HOG PROCESSING FACILITY
CLIENT MANITOBA WATER SERVICES BOARD
JOB No. 0326-049-01-07
DRILLING DATE FEBRUARY 25, 1986
DRILLED BY PADDOCK DRILLING LTD.

TEST BORING No 1

MOISTURE CONTENT — ○
LIQUID LIMIT — □
PLASTIC LIMIT — △

SURFACE ELEVATION 65.60 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean				
	- fine - medium - light brown	1A		8	
2	- dry - loose - sub-angular - uniform - finer with depth - wet at 3.4 m				
3	- trace silt between 3.4 - 3.7 m - dense	2A		31	
4	- medium dense	3A		19	
5					
6		4B			
7	- fine at 7.0 m - grey - uniform				
8	- trace clay at 8.0 m	5B			
	End hole at 8.01 m.				
9					

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PROJECT NEEPAWA HOG PROCESSING FACILITY
CLIENT MANITOBA WATER SERVICES BOARD
JOB No. 0326-049-01-07
DRILLING DATE FEBRUARY 25, 1986
DRILLED BY PADDOCK DRILLING LTD.

TEST BORING No 2

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 64.30 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium	1A		11	
2	- light brown - dry - medium dense - uniform - sub-angular - trace organics at 2.1 m - 2.3 m				
3	- fine at 4.0 m - wet at 4.[illegible] m	2A		17	
4	- dense	3A		40	
5					
6	- grey at 6.[illegible] m	4B			no sample recovery
7	- some silt at 7.0 m	5B			
8	End hole at 8.31 m.				
9					

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PROJECT NEEPAWA HOG PROCESSING FACILITY
CLIENT MANITOBA WATER SERVICES BOARD
JOB No. 0326-049-01-07
DRILLING DATE FEBRUARY 25, 1986
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TEST BORING No 3

MOISTURE CONTENT — ○
LIQUID LIMIT — □
PLASTIC LIMIT — △

SURFACE ELEVATION 64.40 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium - light brown - medium dense - uniform - sub-angular - finer at 2.4 m	1A		18	
2					
3	- wet at 3.9 m - trace organics 3.9 - 4.8 m - brown at 4.0 m	2A		19	
4					
5	- medium dense	3A		12	
6	- very fine at 6.4 m - grey - wet - medium dense - minor silt - 2 mm thick lamiliae				
7		4A		12	
8	- trace clay at 8.0 m				
	End hole at 8.01 m.				
9					

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PROJECT	NEEPAWA HOG PROCESSING FACILITY
CLIENT	MANITOBA WATER SERVICES BOARD
JOB No	0326-049-01-07
DRILLING DATE	FEBRUARY 25, 1986
DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 4

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 64.85 m

CO-ORDINATES
SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium - light brown - dry - loose - uniform - sub-angular - trace Fe oxidation - fine at 2.4 m	1A		6	
2					
3	- dark brown - wet at 3.3 m - medium dense at 3.3 m	2A		12	
4	- medium dense	3A		25	
5	- fine at 5.5 m - grey - wet medium dense - fine - medium sand from 6.7 - 7.6 m	4A		20	
6					
7	- medium dense	5A		21	
8	End hole at 8.01 m				
9					

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PROJECT	NEEPAWA HOG PROCESSING FACILITY
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JOB No.	0326-049-01-07
DRILLING DATE	FEBRUARY 26, 1986
DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 5

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 66.38 m

CO-ORDINATES
SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (kPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean				
	- fine - medium - light brown	1A		26	frost in sample
2	- medium dense - uniform - sub-angular - occasional pebbles and stones from 2.7 - 3.7 m				
3	- trace Fe oxidation	2A		24	
4	- wet at 3.7 m				
5		3A		21	
6	- fine - very fine at 5.8 m - grey - wet - medium dense - uniform				
7		4E			
8	End hole at 7.62 m.				
9					

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DRILLING DATE FEBRUARY 26, 1986
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TEST BORING No 6

SURFACE ELEVATION 65.65 m
CO-ORDINATES SEE SITE PLAN

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (kPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium - light brown - dry - medium dense - sub-angular - occasional stones at 1.7 m	1A		14	
2					
3	- wet at 3.0 m - trace organics from 3.0 to 3.[illegible] m	2A		22	
4					
5	- fine at 4.9 m - grey - wet - dense - some silt from 5.5 - 6.7 m	3A		32	
6					
7					
8	End hole at 7.62 m				
9					

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CLIENT MANITOBA WATER SERVICES BOARD
JOB No 0326-049-01-07
DRILLING DATE FEBRUARY 26, 1986
DRILLED BY PADDOCK DRILLING LTD.

TEST BORING No 7

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 64.50 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - medium - light brown				
2	- dry - medium dense - sub-angular				
3	- wet at 3.0 m				▽
4	- fine at 4.3 m - grey - medium dense - wet				K = 1.5 x 10^{-4} cm/sec
5	- minor silt				
6					6.49 m
7	- trace clay at 7.6 m				7.39 m
8	End hole at 7.62 m.				Piezometer 1
9					

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PROJECT	NEEPAWA HOG PROCESSING FACILITY
CLIENT	MANITOBA WATER SERVICES BOARD
JOB No.	0326-049-01-07
DRILLING DATE	FEBRUARY 26, 1987
DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 8

MOISTURE CONTENT — ○
LIQUID LIMIT — □
PLASTIC LIMIT — △

SURFACE ELEVATION 64.48 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - medium - light brown				
2	- dry - medium dense - sub-angular				
3					
4	- wet at 4.6 m				▽
5					K = 2.3 x 10^{-4} cm/sec
6	- fine at 6. 1 m - grey - medium dense - wet	1E			
7	- trace clay at 7 9 m				7.0 m 7.9 m
8	End hole at 7.9 m.				Piezometer 2
9					

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PROJECT	NEEPAWA HOG PROCESSING FACILITY
CLIENT	MANITOBA WATER SERVICES BOARD
JOB No.	0326-049-01-07
DRILLING DATE	FEBRUARY 26, 1986
DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 9

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 65.38 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - medium - light brown				
2	- dry - medium dense - sub-angular				
3					
4	- wet at 4.3 m - organic lamillae 2 mm thick from 4.3 - 6.9 m	1E			∇ K = 8.4 x 10^{-5} cm/sec
5	- fine at 4.9 m - grey medium dense - minor silt				
6					6.26 m
7	- trace clay at 7.6 m	2E			7.16 m Piezometer 3
8	End hole at 7.62 m.				
9					

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DRILLING DATE FEBRUARY 26, 1986
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TEST BORING No 10

MOISTURE CONTENT ○
LIQUID LIMIT □
PLASTIC LIMIT △

SURFACE ELEVATION 64.99 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium	1E			
2	- light brown - dry - medium dense - sub-angular - uniform - fine at 2.1 m				
3		2E			
	- wet at 3.4 m - minor organics from 3.4 - 4.4 m				
4		3E			
5	End hole at 4.57 m.				
6					
7					
8					
9					

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PROJECT NEEPAWA HOG PROCESSING FACILITY
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DRILLING DATE FEBRUARY 26, 1986
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TEST BORING No 11

MOISTURE CONTENT — ○
LIQUID LIMIT — □
PLASTIC LIMIT — △

SURFACE ELEVATION 63.80 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - medium - light brown	1E			
2	- dry - medium dense - sub-angular - uniform				
3		2E			
4	- wet at 3.7 m - fine - trace organic from 3.7 - 4.5 m	3E			
5	End hole at 4.57 m.				
6					
7					
8					
9					

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JOB No. 0326-049-01-07

DRILLING DATE FEBRUARY 26, 1986

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TEST BORING No 12

MOISTURE CONTENT — ○
LIQUID LIMIT — □
PLASTIC LIMIT — △

SURFACE ELEVATION 63.20 m

CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL PROFILE	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS	DEPTH (metres)
		TOP SOIL - silty - black - organic					
1		SAND - clean - fine - medium - light brown - dry - medium dense - sub-angular - uniform	1E				
2							
3		- wet at 3.0 m	2E				
4		- fine at 3.7 m - grey - some silt	3E				
5		End hole at 4.57 m.					
6							
7							
8							
9							

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PROJECT NEEPAWA HOG PROCESSING FACILITY
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TEST BORING No. 13

MOISTURE CONTENT ○
LIQUID LIMIT □
PLASTIC LIMIT △

SURFACE ELEVATION 65.37 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL PROFILE	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS	DEPTH (metres)
		TOP SOIL - silty - black - organic					
1		SAND - clean - medium - light brown - medium dense - sub-angular - uniform	1E				
2							
3		- some organics and Fe oxidation from 2.6 - 3.0 m	2E				
4		- wet at 4.3 m	3E				
5		End hole at 4.57 m.					
6							
7							
8							
9							

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DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 14

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 65.70 m

CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium - light brown - dry - medium dense - sub-angular - uniform	1E			
2					
3	- wet at 3.0 m				
4	- dark brown at 3.7 m - some organics	2E			
		3E			
5	End hole at 4.57 m				
6					
7					
8					
9					

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PROJECT NEEPAWA HOG PROCESSING FACILITY
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DRILLING DATE FEBRUARY 26, 1986
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TEST BORING No 15

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 65.95 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - medium - light brown				
2	- dry - medium dense - sub-angular - occasional pebbles at 1.5 m	1E			
3	- wet at 3.0 m	2E			
4	- minor organics at 4.0 m - dark brown	3E			
	End hole at 4.57 m.				
5					
6					
7					
8					
9					

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PROJECT NEEPAWA HOG PROCESSING FACILITY
CLIENT MANITOBA WATER SERVICES BOARD
JOB No 0326-049-01-07
DRILLING DATE FEBRUARY 26, 1986
DRILLED BY PADDOCK DRILLING LTD.

TEST BORING No 16

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 64.51 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium - light brown				
2	- dry - medium dense - sub-angular - uniform	1E			
3		2E			
4	- wet at 3.7 m				
		3E			
5	End hole at 4.57 m.				
6					
7					
8					
9					

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PROJECT	NEEPAWA HOG PROCESSING FACILITY
CLIENT	MANITOBA WATER SERVICES BOARD
JOB No.	0326-049-01-07
DRILLING DATE	FEBRUARY 26, 1986
DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 17

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 64.73 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (kPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - light brown - dry - medium dense - sub-angular - uniform				
2		1E			
3		2E			
4	- wet at 4.2 m	3E			
5	End hole at 4.57 m.				
6					
7					
8					
9					

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PROJECT	NEEPAWA HOG PROCESSING FACILITY
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JOB No.	0326-049-01-07
DRILLING DATE	FEBRUARY 26, 1986
DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 18

MOISTURE CONTENT ○
LIQUID LIMIT □
PLASTIC LIMIT △

SURFACE ELEVATION 65.30 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS	DEPTH (metres)
	TOP SOIL - silty - black - organic					
1	SAND - clean - fine ~ medium - light brown					
	- dry	1E				
2	- medium dense - sub-angular - uniform - fine at 2.4 m					
3		2E				
4	- wet 4.0 m - brown at 4.0 m					
		3E				
	End hole at 4.57 m.					
5						
6						
7						
8						
9						

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PROJECT NEEPAWA HOG PROCESSING FACILITY
CLIENT MANITOBA WATER SERVICES BOARD
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DRILLING DATE FEBRUARY 26, 1986
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TEST BORING No 19

SURFACE ELEVATION 64.51 m
CO-ORDINATES SEE SITE PLAN

MOISTURE CONTENT —— ○
LIQUID LIMIT —— □
PLASTIC LIMIT —— △

DEPTH (metres)	SOIL PROFILE	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS	DEPTH (metres)
		TOP SOIL - silty - black - organic					
1		SAND - clean - fine - medium - light brown					
2		- dry - medium dense - sub-angular - uniform	1E				
3		- wet at 3.4 m - dark brown at 3.4 m	2E				
4			3E				
5		End hole at 4.57 m.					
6							
7							
8							
9							

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DRILLING DATE FEBRUARY 26, 1986
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TEST BORING No 20

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION 61.77 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS	DEPTH (metres)
	TOP SOIL - silty - black - organic					
1	SAND - clean - fine - medium					
	- light brown	1E				
2	- dry - medium dense - sub-angular - uniform - wet at 1.9 m - fine at 2.1 m					
3	- grey - wet - medium dense	2E				
4		3E				
5	End hole at 4.57 m.					
6						
7						
8						
9						

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PROJECT NEEPAWA HOG PROCESSING FACILITY
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DRILLING DATE FEBRUARY 27, 1986
DRILLED BY PADDOCK DRILLING LTD.

TEST BORING No. 21

MOISTURE CONTENT ○
LIQUID LIMIT □
PLASTIC LIMIT △

SURFACE ELEVATION 63.35 m
CO-ORDINATES SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (kPa)	STANDARD PENETRATION (Blows/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - fine - medium - light brown - dry - medium dense - sub-angular - uniform	1E			
2					
3	- fine and grey at 3.2 m	2E			
4		4E			
5	- wet at 4.9 m				
6		5E			
7	- grey with silt at 7.1 m				
8	SILT - sandy - dark grey - moist - firm - plastic	6E			
9	End hole at 9.14 m.				

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PROJECT: NEEPAWA HOG PROCESSING FACILITY
CLIENT: MANITOBA WATER SERVICES BOARD
JOB No.: 0326-049-01-07
DRILLING DATE: FEBRUARY 27, 1986
DRILLED BY: PADDOCK DRILLING LTD.

TEST BORING No. 22

MOISTURE CONTENT ——— ○
LIQUID LIMIT ——— □
PLASTIC LIMIT ——— △

SURFACE ELEVATION: 65.03 m
CO-ORDINATES: SEE SITE PLAN

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC. TESTS & REMARKS
	TOP SOIL - silty - black - organic				
1	SAND - clean - medium - light brown - dry - medium dense - sub-angular - occasional pebbles - white flakey material from 1.5 - 1.8 m	1G 2B			
2					
3	- fine at 2.7 m - organic lamillae at 3.2 - 3.5 m - minor Fe oxidation	3E			
4	- wet at 4.3 m	4E			
5					
6	- very fine with silt at 5.8 m - grey				
7					
8		5E			
9	SILT - sandy - trace clay	6B			

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PROJECT	NEEPAWA HOG PROCESSING FACILITY
CLIENT	MANITOBA WATER SERVICES BOARD
JOB No.	0326-049-01-07
DRILLING DATE	FEBRUARY 27, 1986
DRILLED BY	PADDOCK DRILLING LTD.

TEST BORING No 22

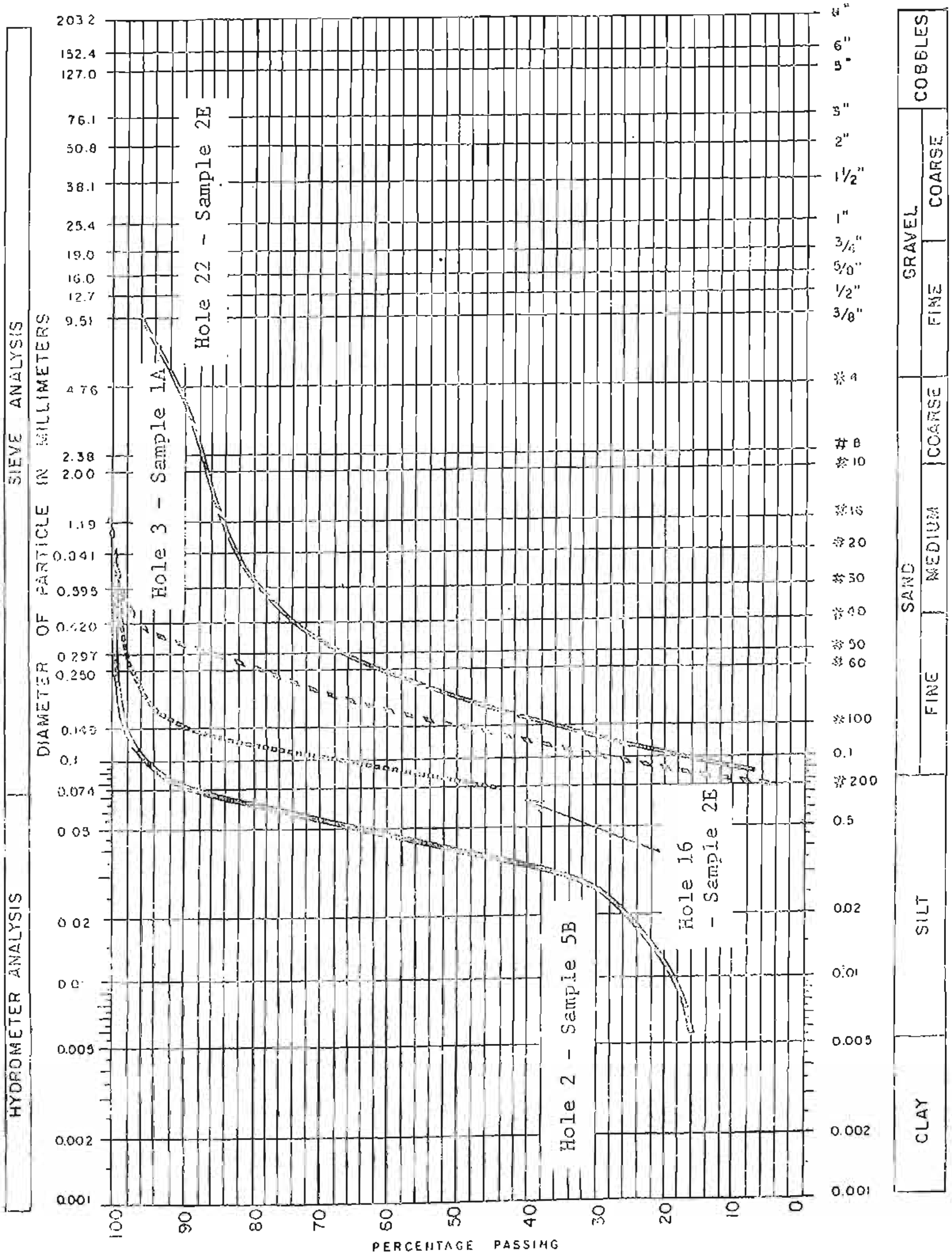
MOISTURE CONTENT ○
LIQUID LIMIT □
PLASTIC LIMIT △

DEPTH (metres)	SOIL PROFILE	SURFACE ELEVATION 65.03 m CO-ORDINATES SOIL DESCRIPTION	SAMPLE NO. & TYPE	COMPRESSIVE STRENGTH (KPa)	STANDARD PENETRATION (BLOWS/0.3 m)	MISC TESTS & REMARKS	DEPTH (metres)
		- dark grey - moist - ~~firm~~ - plastic					
10		End hole at 9.60 m					

APPENDIX B

LABORATORY TEST RESULTS

GRADATION ANALYSIS



$C_u = \frac{D_{60}}{D_{10}} =$

$C_c = \frac{(D_{30})^2}{(D_{60})(D_{10})} =$

SAMPLE DESCRIPTION

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JOB NO. 0326-049-01-07 DATE: MARCH 1986

PROJECT HOG PROCESSING FACILITY

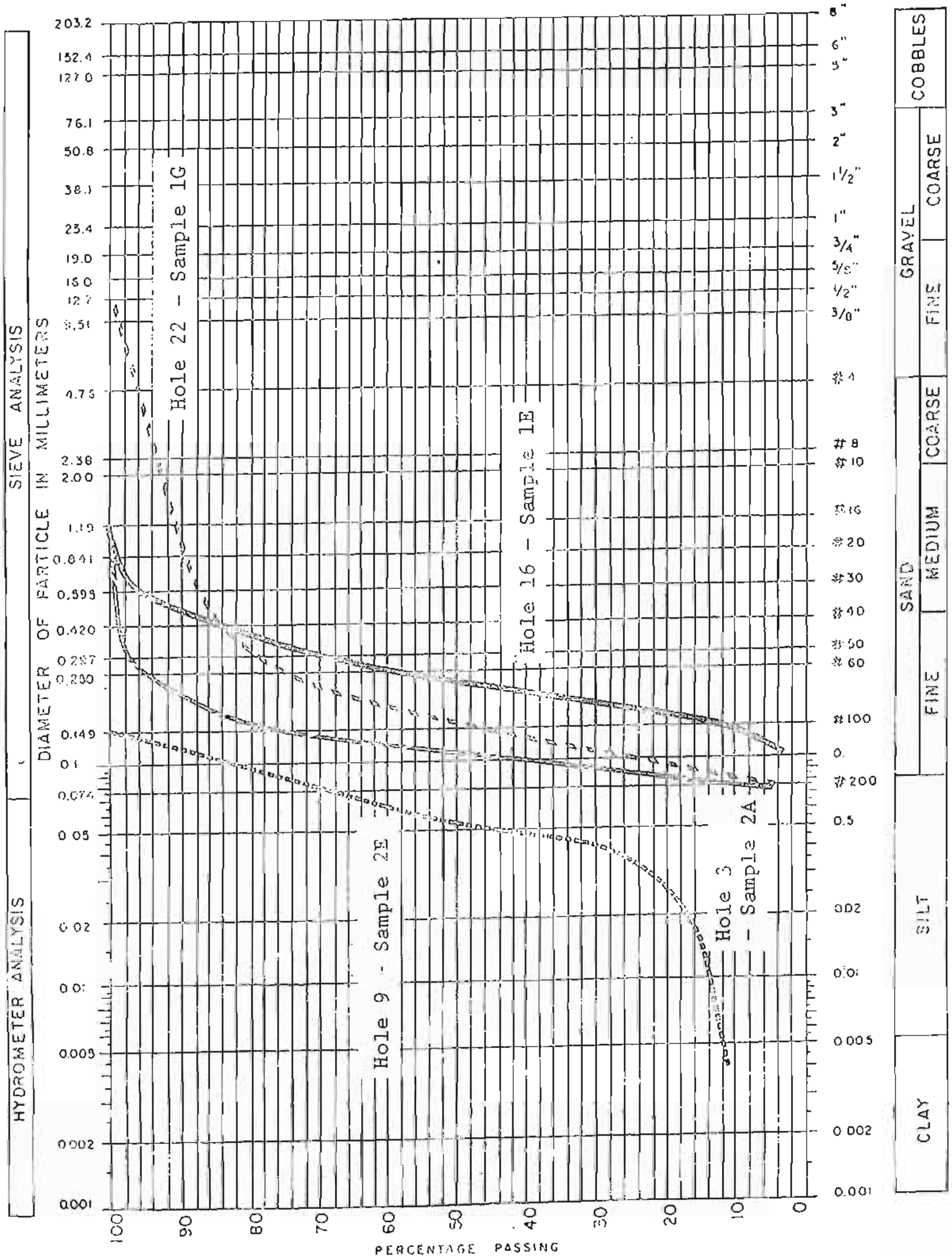
SITE

LOCATION NEEPAWA

HOLE NO. SAMPLE NO.

DEPTH TECHNICIAN:

GRADATION ANALYSIS



$Cu = \frac{D_{60}}{D_{10}} =$

$Cc = \frac{(D_{30})^2}{(D_{60})(D_{10})} =$

SAMPLE DESCRIPTION

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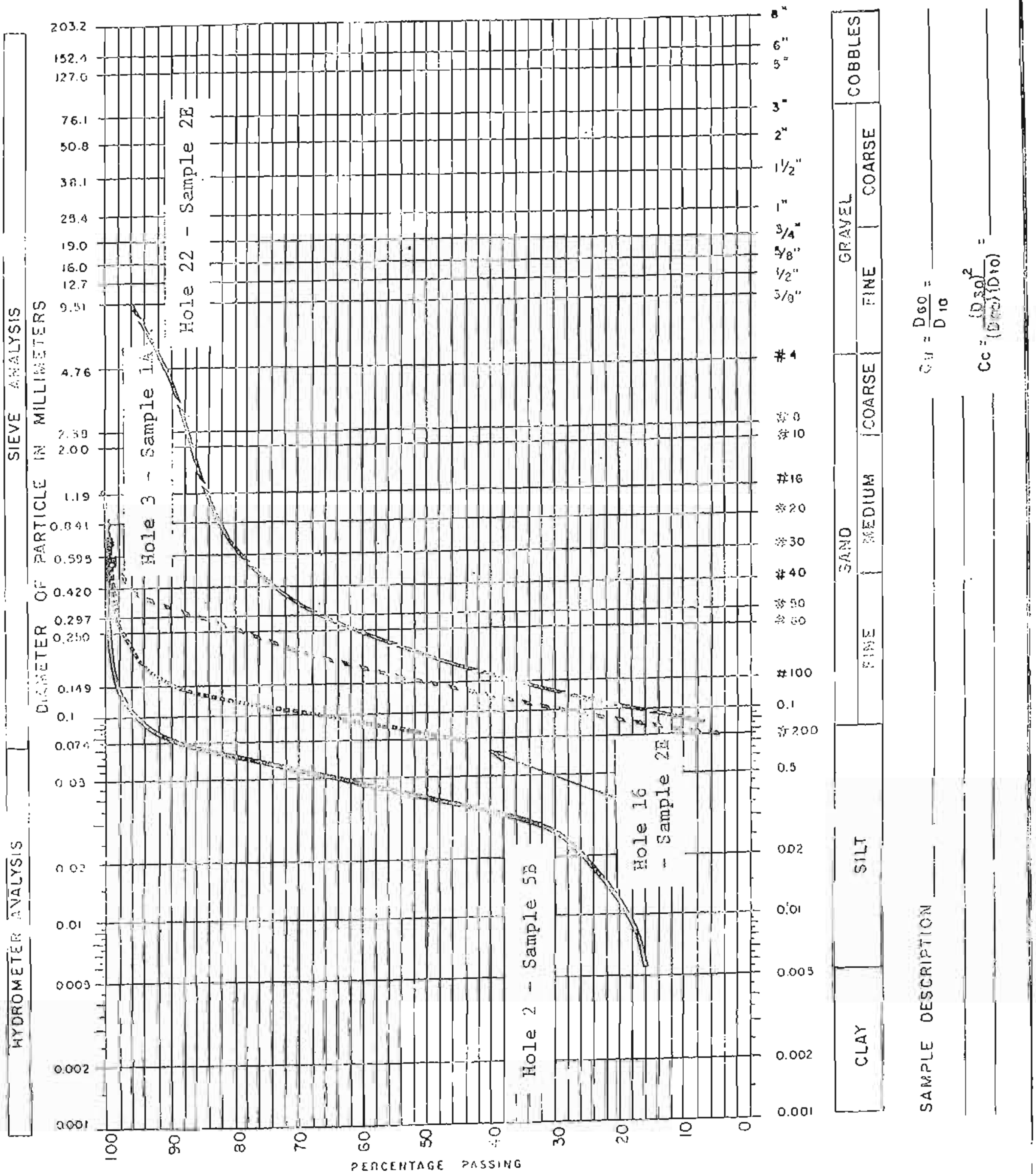
JOB NO 0326-049-01-07 DATE: MARCH 1986
PROJECT: HOG PROCESSING FACILITY
SITE:
LOCATION: NEEPAWA
HOLE NO.: SAMPLE NO.:
DEPTH TECHNICIAN:

GRADATION ANALYSIS



JOB NO.: 0326-049-01-07	DATE: MARCH 1986
PROJECT: HOG PROCESSING FACILITY	
SITE:	
LOCATION: NEEPAWA	
HOLE NO.:	SAMPLE NO.:
DEPTH:	TECHNICIAN:

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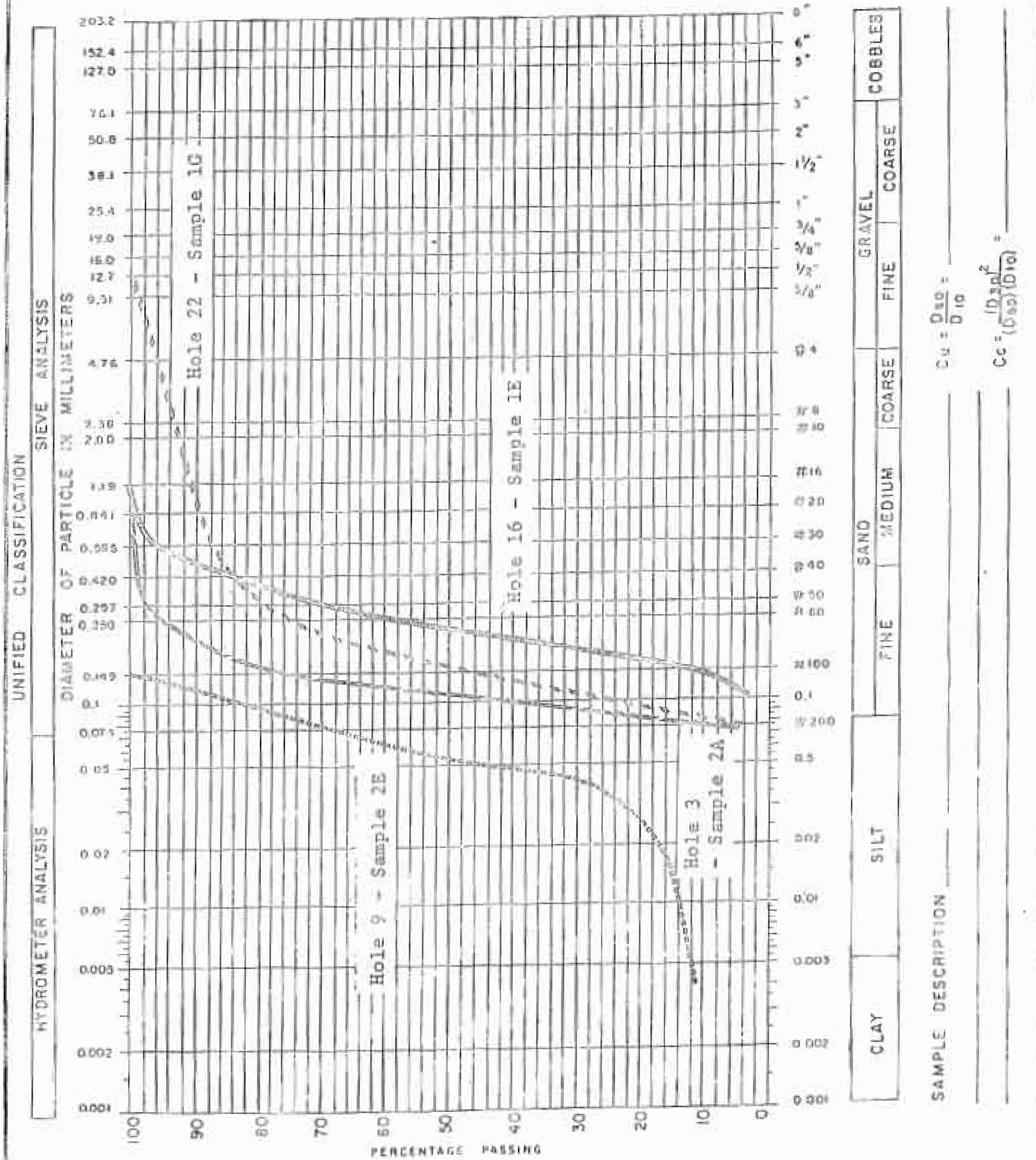
GRADATION ANALYSIS



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JOB NO 0326-049-01-07 DATE MARCH 1986
PROJECT HOG PROCESSING FACILITY
SITE
LOCATION NEEPAWA
HOLE NO. SAMPLE NO
DEPTH TECHNICIAN

APPENDIX C

CLAY LINER BORROW INVESTIGATION

APPENDIX C
CLAY LINER BORROW INVESTIGATION

C.1 INTRODUCTION

With the decision to use a clay liner for seepage control, an investigation was undertaken to confirm the quantity and quality of potential borrow sources. Available soils and geologic reports were reviewed to define potential areas of suitable soils. Highways officials and local contractors were contacted to determine what sources of fine grained soils had previously been utilized for roadway construction.

C.2 RECONNAISSANCE EVALUATION

Based on the information collected above, a site visit was completed to visually evaluate all possible borrow sources. Drawing C-1 shows the sites visited during the reconnaissance. Based on location and visual examination of suitability for the clay liner, four sites were selected for lab testing (Sites 1, 2, 7 and 8 on Drawing C-1).

Materials testing on these four sites consisted of establishing gradation, plasticity index and moisture content. The results of this testing are summarized below. Gradation analysis sheets are attached.

	Percent By Weight							
Site	Clay	Silt	Sand	P.L.	L.L.	P.I.	W%	Remarks
1	34.0	36.5	29.5	21.2	40.6	19.4	22.6	sample from stockpile
2	44.0	36.9	19.1	21.2	42.4	21.2	31.7	pit wall sample
7	29.4	54.4	16.2	15.7	22.6	6.9	18.2	sample from stockpile source location unknown
8	39.7	48.6	11.7	16.9	40.6	23.7	25.8	sample from stockpile

With these test results, and in consideration of the proximity to the construction site, more detailed evaluation focused on areas 1 and 2. A standard proctor density test and lab permeability test were completed on material collected from area 2 and the results are attached. It should be pointed out that a vacuum was applied to the permeameter cell to induce a flow through the sample. It is considered that the measured permeability of 5 x 10^{-10} m/s may have been influenced by the vacuum applied to the sample and that the true permeability of the material is lower. The test is currently being repeated with no suction on the sample. At the time of writing, no water has drained through the sample.

A revised permeability cannot be re-calculated at this time, however, the revised value is expected to be lower than the initial value of 5 x 10^{-10} m/s. The Standard Proctor value for the material at site 2 was determined to be 106.7 pcf at 19% moisture.

C.3 DETAILED INVESTIGATION

The site reconnaissance and initial lab work identified the presence of a suitable borrow source for the liner in the area of site 2. To confirm sufficient volumes for liner construction and to identify any variability in the material with depth, a second field investigation was completed. Drawing C 2 shows the location of the two sites test pitted.

Materials testing on the detailed sites consisted of establishing gradation analysis, plasticity index and moisture contents. The results of this testing are summarized on the test hole logs and gradation analysis sheets attached.

C.4 DISCUSSION

The detailed site investigation has identified a source of at least 120,000 cubic metres for the clay liner. For the area studied, this is based on an area of 500 m by 120 m with a minimum 3 metre depth.

From discussions with local contractors, closer sources may be available but the contractors held the locations in confidence.

Swelling is likely to occur when plastic compacted clays are inundated with water. The clays tested generally have a medium to high swelling potential with activities that range from .48 to .83. The average percent swell was estimated using the following equation:

$$S = 3.6 \times 10^{-5} (A)^{2.44} (C)^{3.4} \qquad (C.1)$$

Where: S = percent swell for laterally confined samples under a 7 kPa surcharge

A = activity

C = clay content (< .002 mm)

Effective stresses due to the effective weight of the liner material and seepage forces will generally average about 7 kPa in the upper half of the compacted clay liner under levels of about 1.5 metres. Using equation C.1, the percent swell for the clay was estimated at 2.4%.

The swelling potential was also calculated using the plasticity index as follows:

$$S = 2.16 \times 10^{-3} (P.I.)^{2.44} \qquad (C.2)$$

Where: S = swelling potential
P.I. = plasticity index

Using equation C.2, the swelling potential of the clay was calculated to be 4.4%.

The results indicate that swelling potential can be considered to be medium, thus the problems associated with very high swelling clay liners should not be encountered with the clay material tested.

Piping erosion of the liner is a serious problem that could lead to the failure of the liner and eventually erosion of the dyke. Piping occurs when preferential seepage along fissures or beside pipes and structures washes away fines. These conditions can be avoided as follows:

(a) providing sufficient compaction of materials beside pipes and structures.

(b) employing seepage cutoffs when necessary.

(c) ensuring that all adjacent materials along seepage paths meet standard filter criteria

The first two conditions can be provided during the design and construction inspection of the lagoon dykes.

The following filter criteria were checked for the clay liner-sand fill interface:

(a) Piping Criteria

The 15 percent size (D15) of the sand fill must not be more than four or five times the 85 percent size (D85) of the liner. The ratio of D15 of the sand fill to D85 of the clay liner is called the piping ratio and is approximately 0.3. This ratio is low and is well below the piping ratio criteria of less than 4 to 5. As an added factor of safety against piping erosion, we would recommend that a geotextile filter cloth be placed between the clay liner and sand fill at all piping and structure locations.

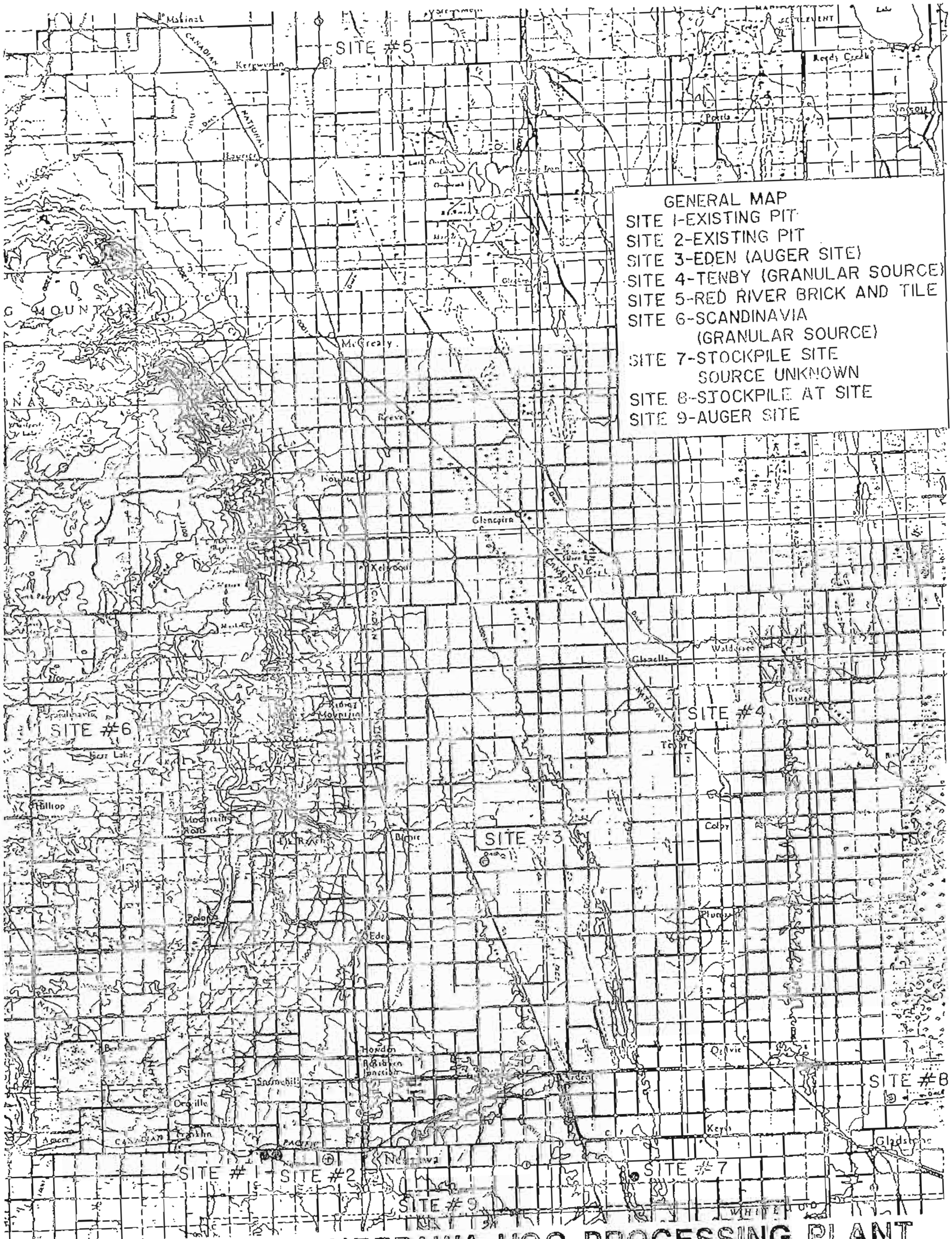
(b) Permeability Criteria

The 15 percent size (D15) of the sand fill must be at least 4 or 5 times the 15 percent size of the clay liner. This requirement will generally ensure that filter layers will be several times more permeable than adjacent soils. The permeability ratio for the clay liner and sand fill is greater than 5 indicating that a sufficient permeability contrast exists.

As mentioned previously, the constant head permeater test of material from test site A is being re-run with no vacuum applied to induce flow. Based on the gradation and index properties, it is expected that the source tested will have a permeability of 1×10^{-10} m/s or less.

C.5 CONCLUSIONS

The borrow study has determined that at least one source of suitable material, in sufficient volume (Site A), is available for lining the lagoon. Prior to the start of liner construction, the source proposed by the Contractor should be tested for gradation, Atterberg Limits, moisture content, Proctor density and lab permeability to approve its use on the project.

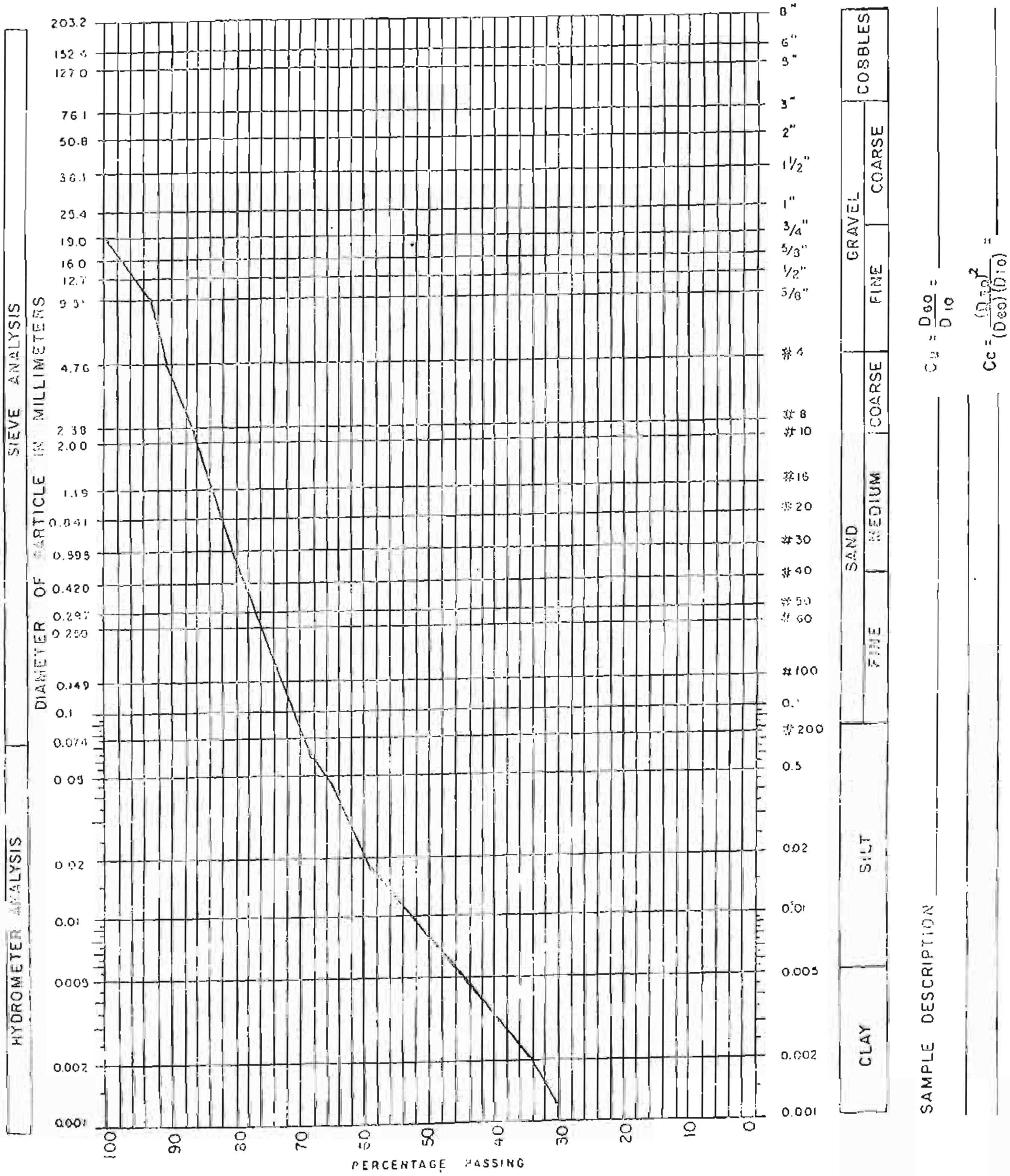


NEEPAWA HOG PROCESSING PLANT

C-1

GENERAL SITE PLAN

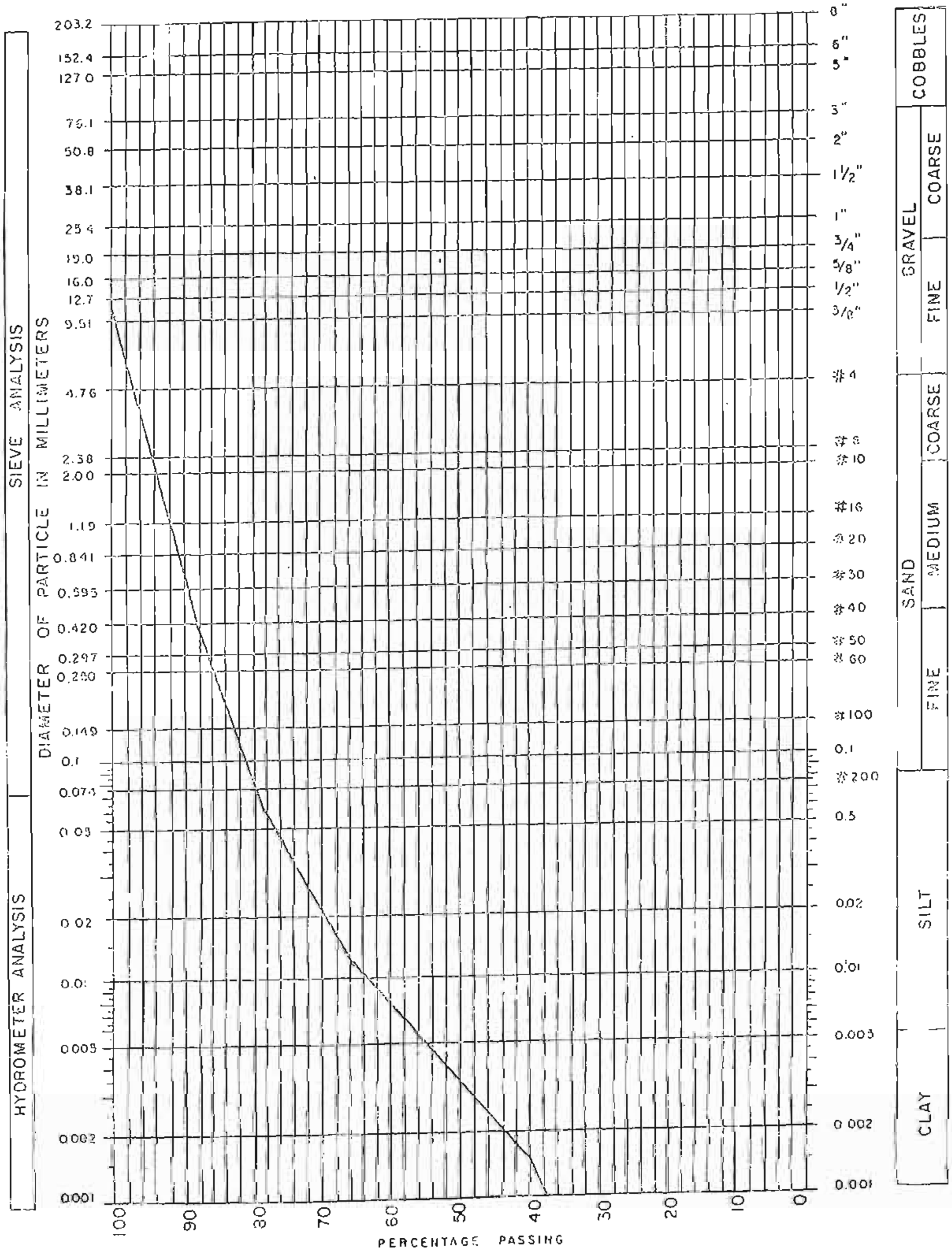
GRADATION ANALYSIS



JOB NO. 0326-049-01	DATE: MAY 1, 1986
PROJECT: NEEPAWA HOG PROCESSING PLANT	
SITE: #1	
LOCATION: AS PER GENERAL SITE PLAN C-1	
HOLE NO.	SAMPLE NO.
DEPTH:	TECHNICIAN: T.H.

UMA Engineering Ltd
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

GRADATION ANALYSIS



$C_u = \frac{D_{60}}{D_{10}} =$

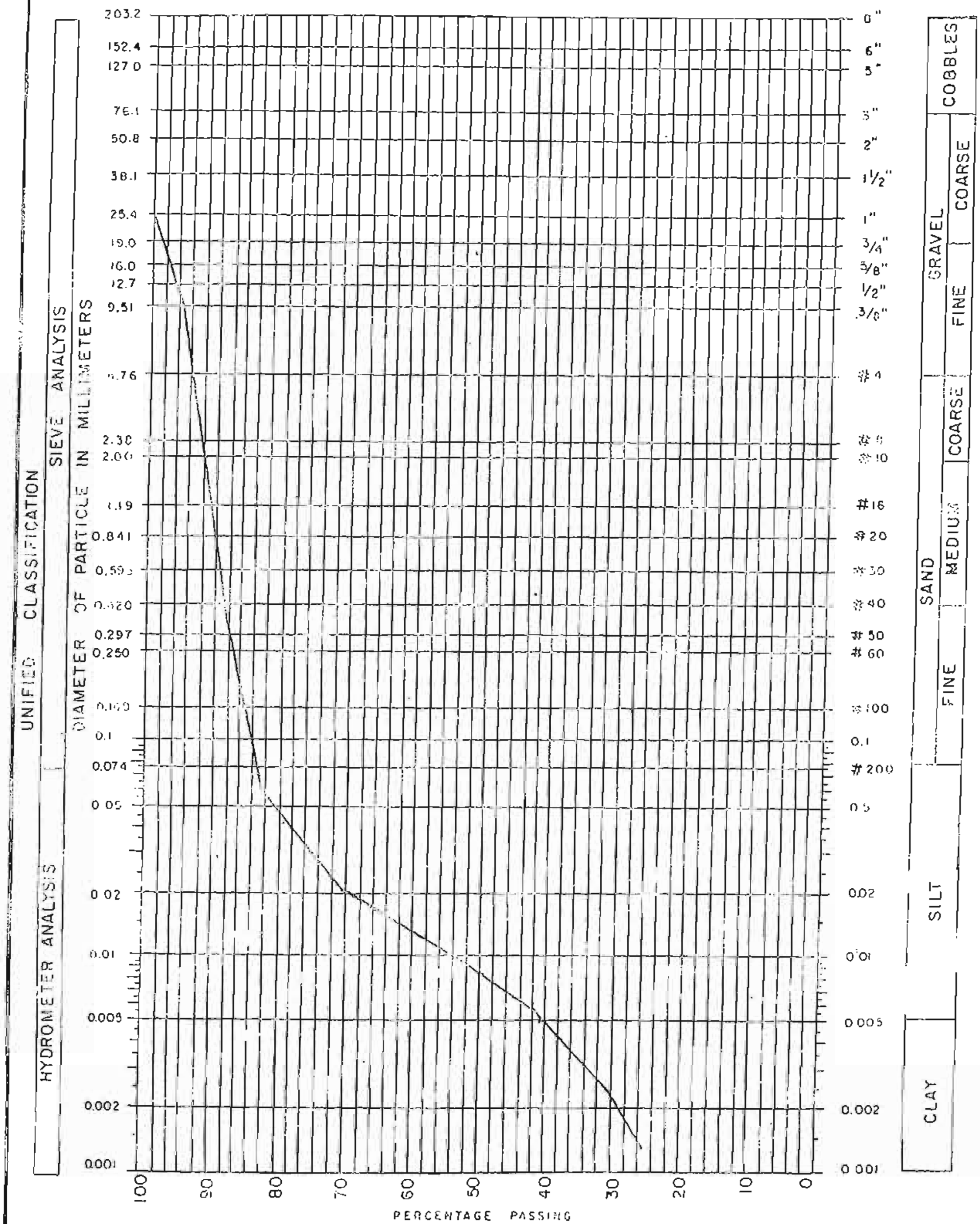
$C_c = \frac{(D_{30})^2}{(D_{60})(D_{10})} =$

SAMPLE DESCRIPTION

UMA Engineering Ltd
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

JOB NO.: 0326-049-01	DATE: MAY 1, 1986
PROJECT: NEEPAWA HOG PROCESSING PLANT	
SITE: #2	
LOCATION: AS PER GENERAL SITE PLAN C-1	
HOLE NO.:	SAMPLE NO.:
DEPTH:	TECHNICIAN: T.H.

GRADATION ANALYSIS



$Cu = \frac{D_{60}}{D_{10}}$ =

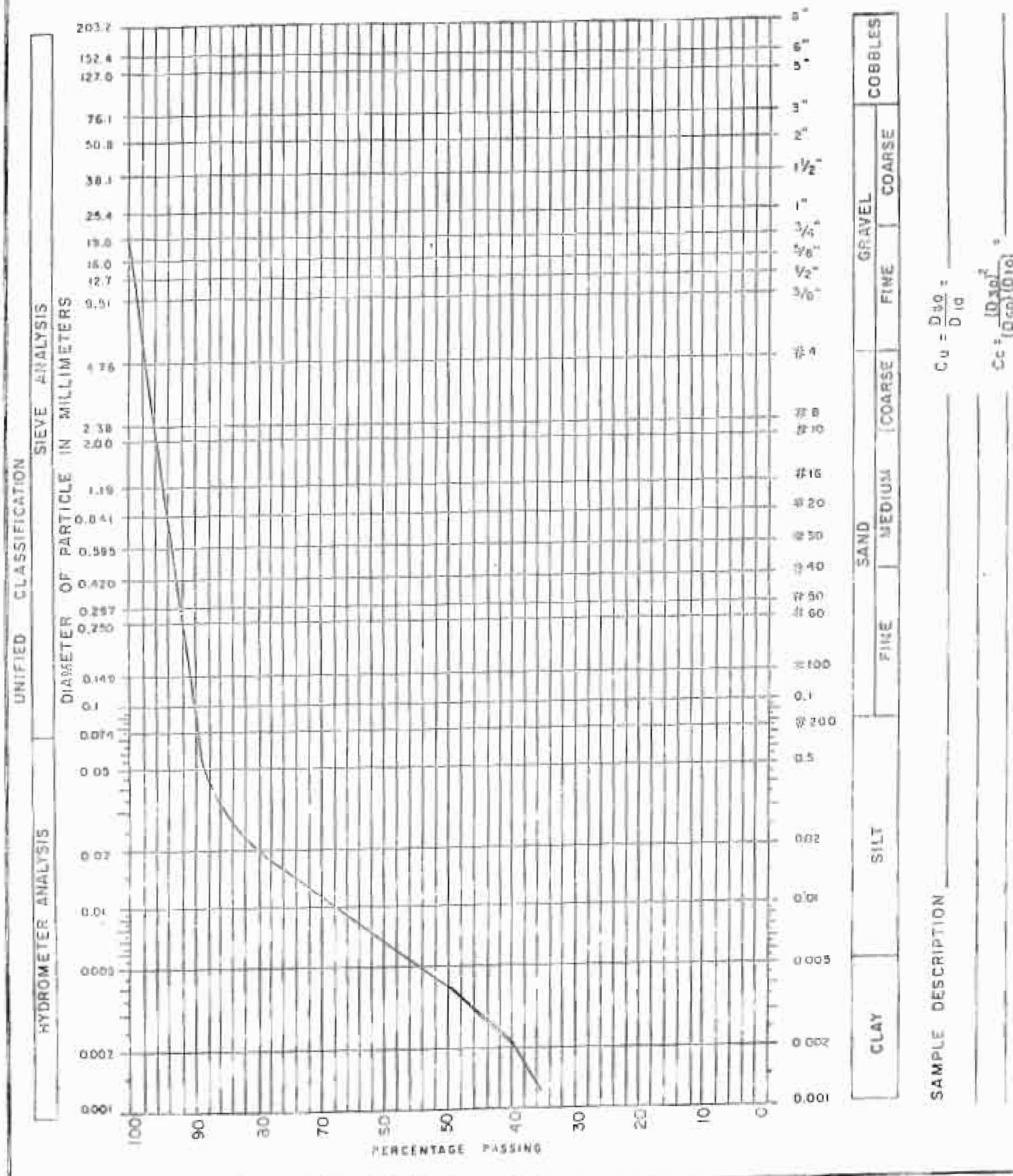
$Cc = \frac{(D_{30})^2}{(D_{60})(D_{10})}$ =

SAMPLE DESCRIPTION

JOB NO. 0326-049-01	DATE: MAY 1, 1986
PROJECT: NEEPAWA HOG PROCESSING PLANT	
SITE: #7	
LOCATION AS PER GENERAL SITE PLAN C-1	
HOLE NO	SAMPLE NO.
DEPTH	TECHNICIAN: T.H.

UMA Engineering Ltd.
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

GRADATION ANALYSIS



SAMPLE DESCRIPTION

UMA Engineering Ltd.
Engineers & Planners
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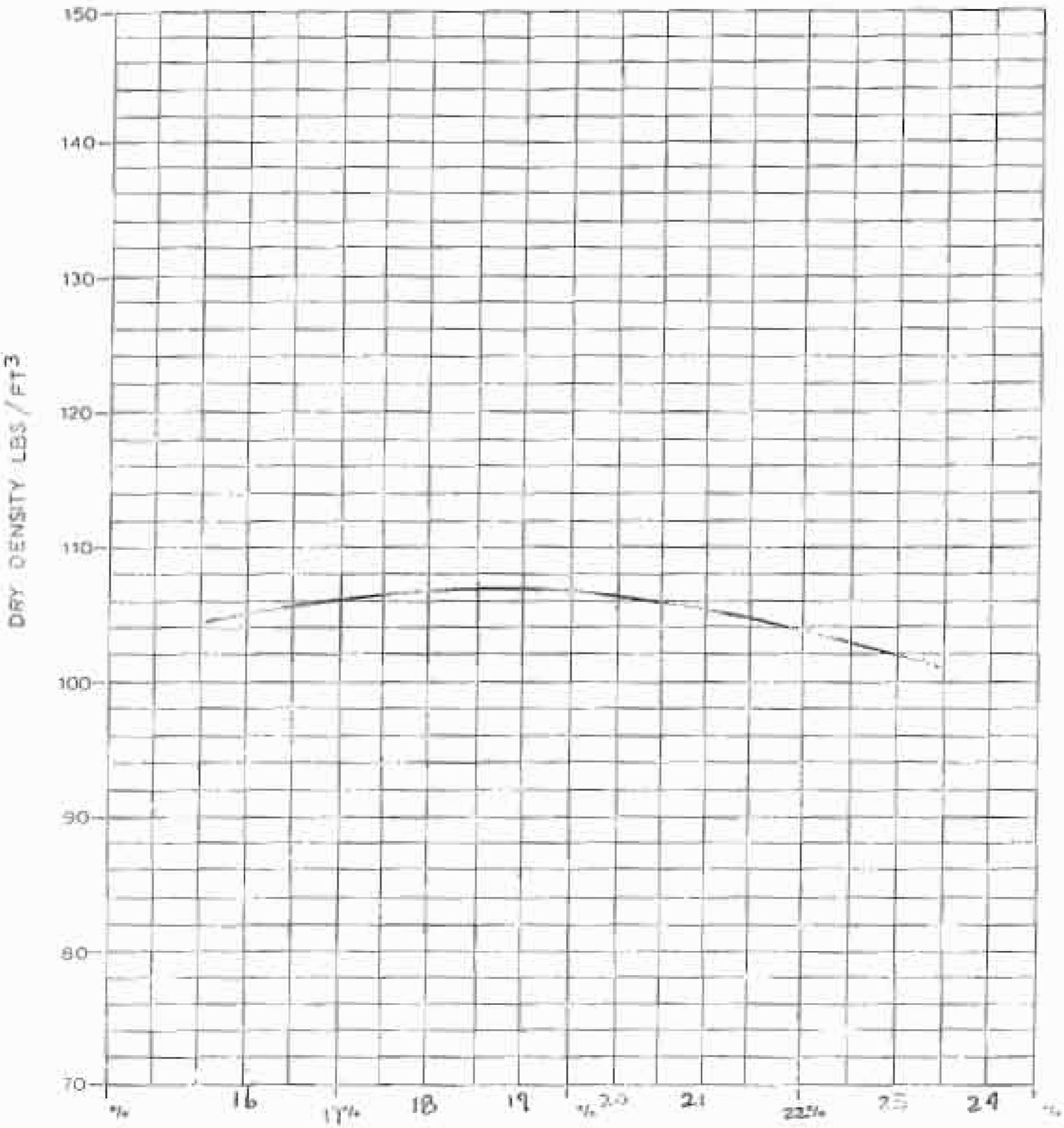
JOB NO. 0326-049-01 DATE MAY 1, 1986
PROJECT NEEPAWA HOG PROCESSING PLANT
SITE #8
LOCATION AS PER GENERAL SITE PLAN C-1
HOLE NO. SAMPLE NO.
DEPTH TECHNICIAN T.H.

PROCTOR DENSITY



WATER CONTENT PERCENTAGE OF DRY WEIGHT

METHOD OF COMPACTION . STANDARD/MODIFIED.

OPTIMUM MOISTURE CONTENT 19 % PROCTOR DENSITY 106.7 LBS/FT3

SAMPLE No. Site #2

TEST PIT/ HOLE As per general site

DEPTH plan C-1

TYPE OF SOIL Clay - Brown - with silt

Underwood McLellan (1977) Ltd.

Consulting Engineers and Planners

TESTING LABORATORY WINNIPEG

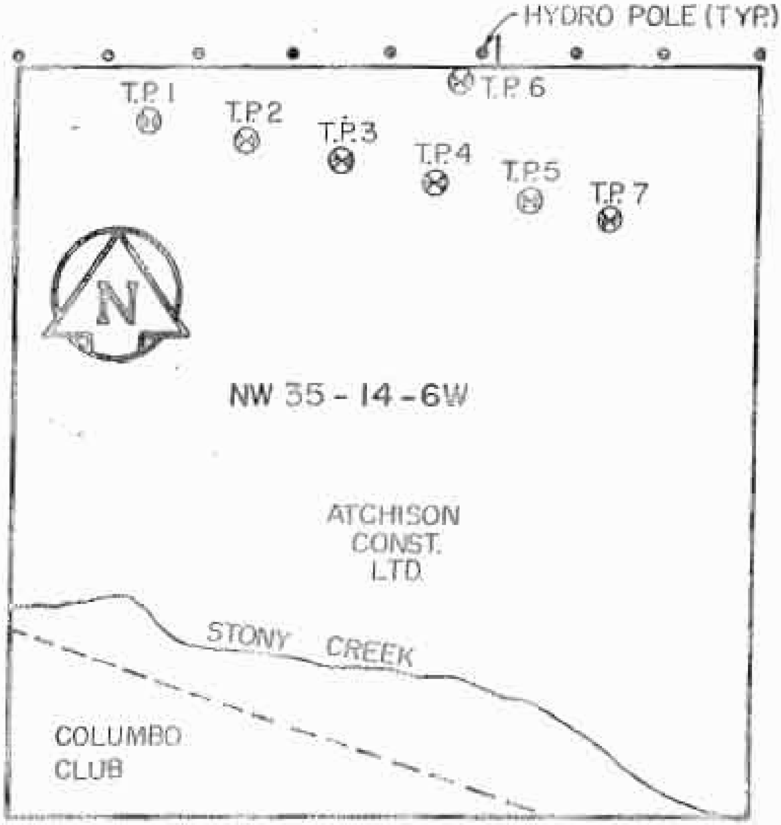
JOB NO. 0326-049-01 DATE MAY 11, 1986

PROJECT NEEPAWA HOG PROCESSING PLANT

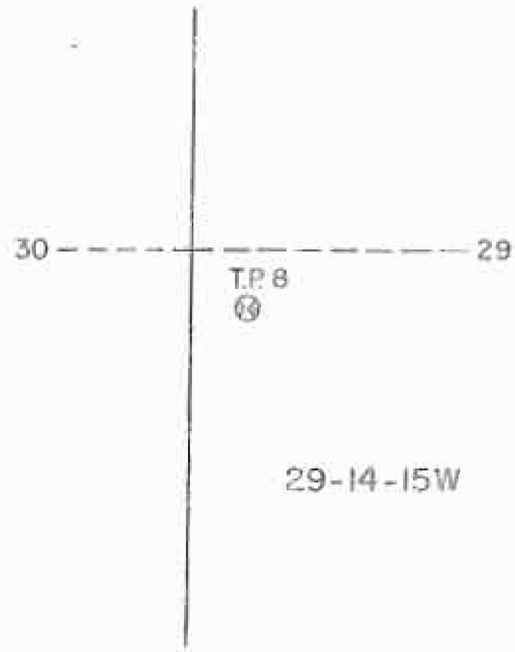
SUBJECT

PLATE

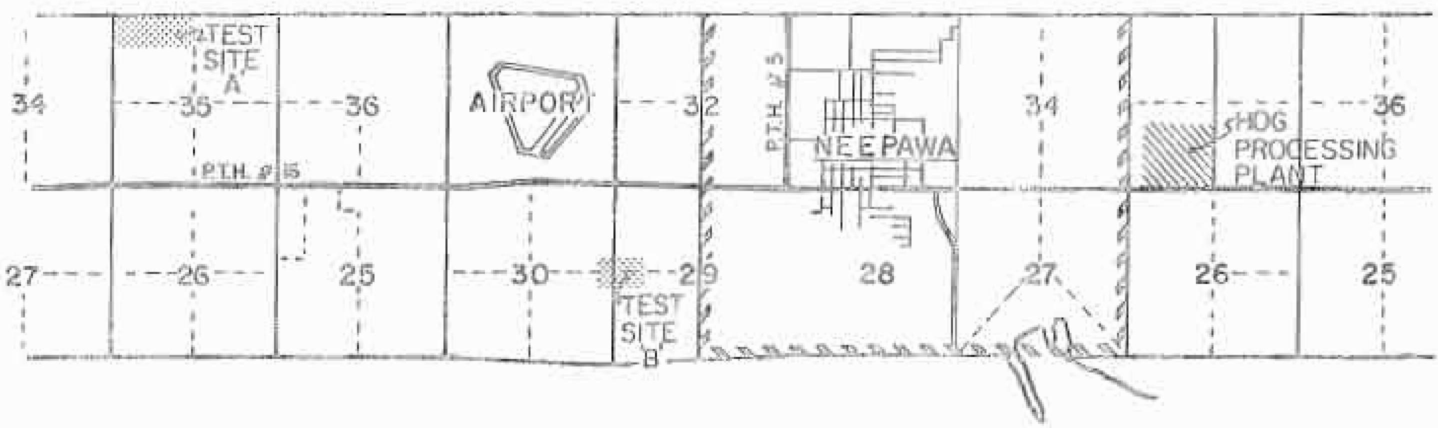
APPROVED



SITE 'A'



SITE 'B'



LOCATION MAP

N.T.S.

NEEPAWA HOG PROCESSING PLANT

DETAILED SITE INVESTIGATION **C-2**

The UMA Group

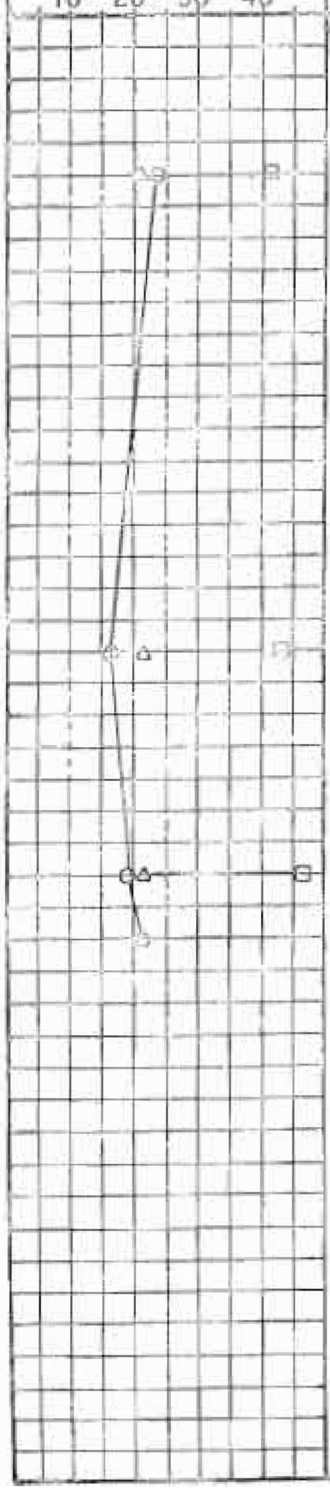
PROJECT NEEPAWA HOG PROCESSING PLANT
CLIENT MANITOBA WATER SERVICES BOARD
JOB NUMBER 0326-049-01 DATE MAY 30, 1986

TEST HOLE 1
SHEET 1 of 8
CHECKED ____ DRAWN TH

TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △

10 20 30 40



DEPTH (METERS)	SOIL PROFILE	SURFACE ELEVATION ____ / CO-ORDINATES / SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F	MISC. TESTS & REMARKS
		TOPSOIL				
		CLAY - brown - with silt - some sand and gravel				
1						
2						
3						
		End of hole @ 3.4 m.				

The UMA Group

PROJECT: NEEPAWA HOG PROCESSING PLANT
CLIENT: MANITOBA WATER SERVICES BOARD
JOB NUMBER: 0326-049-01 DATE: MAY 30, 1986

TEST HOLE: 2
SHEET 2 of 8
CHECKED: DRAWN: TH

TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △
10 20 30 40

SURFACE ELEVATION
CO-ORDINATES

DEPTH (METERS)	SOIL PROFILE	SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F.	MISC. TESTS & REMARKS
		TOPSOIL				
		CLAY - brown - with silt - some sand and gravel				
1						
2						
		- little shale				
3						
		End of hole @ 3.65 m.				

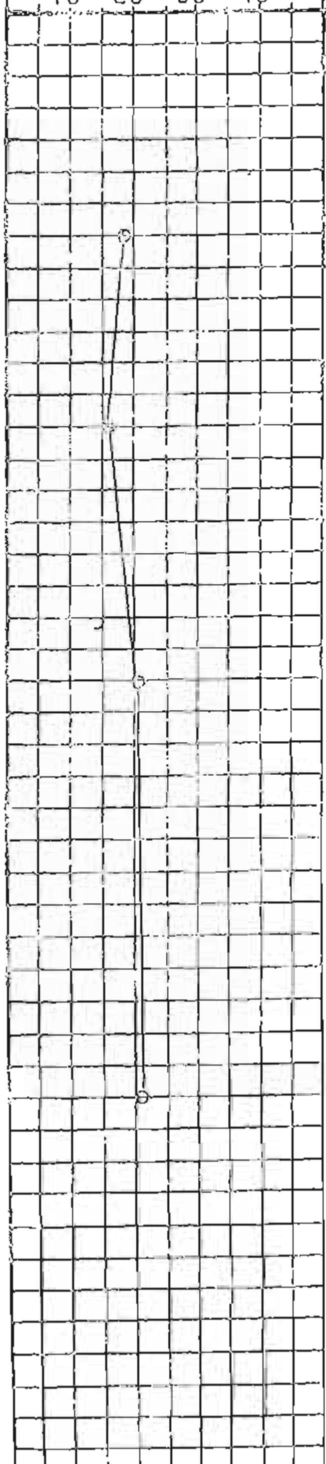
The UMA Group

PROJECT: NEEPAWA HOG PROCESSING PLANT
CLIENT: MANITOBA WATER SERVICES BOARD
JOB NUMBER: 0326-049-01 DATE: MAY 30, 1986

TEST HOLE: 3
SHEET: 3 of 8
CHECKED: ____ DRAWN: TH

TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △
10 20 30 40



DEPTH (METERS)	SOIL PROFILE	SURFACE ELEVATION ____ / CO-ORDINATES / SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F	MISC. TESTS & REMARKS
		TOPSOIL				
1, 2, 3		CLAY - brown - with silt - some sand and gravel				
		End of hole @ 3.4 m.				

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PROJECT NEEPAWA HOG PROCESSING PLANT
CLIENT MANITOBA WATER SERVICES BOARD
JOB NUMBER 0326-049-01 DATE MAY 30, 1986

TEST HOLE 4
SHEET 4 of 8
CHECKED ______ DRAWN TH

TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △
10 20 30 40

SURFACE ELEVATION ______
CO-ORDINATES

DEPTH (METERS)	SOIL PROFILE	SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F	MISC. TESTS & REMARKS
		TOPSOIL				
		CLAY - brown - with silt - some sand and gravel				
1						
2		- traces of shale				
3						
		End of hole @ 3.2 m.				

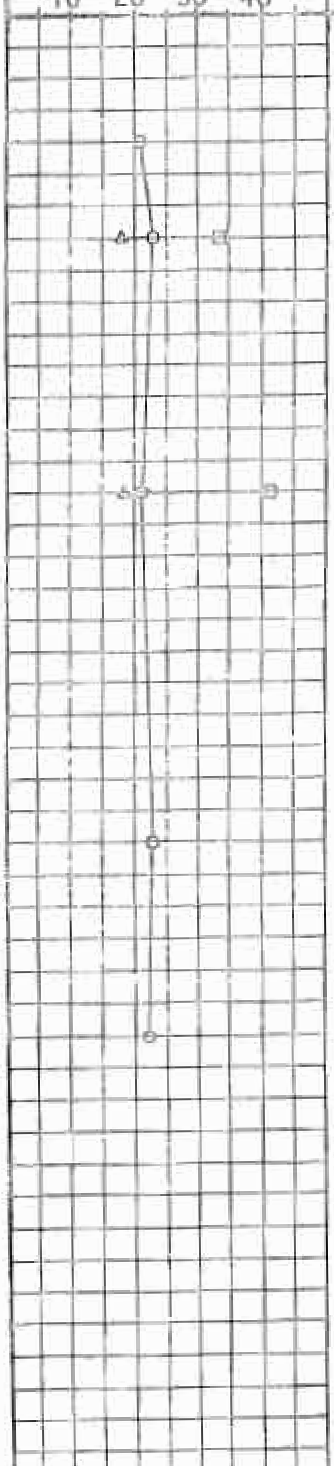
The UMA Group

PROJECT NEEPAWA HOG PROCESSING PLANT
CLIENT MANITOBA WATER SERVICES BOARD
JOB NUMBER 0326-049-01 DATE MAY 30, 1986

TEST HOLE 5
SHEET 5 of 8
CHECKED ______ DRAWN TH

TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △
10 20 30 40



DEPTH (METERS) | SOIL PROFILE

SURFACE ELEVATION ______
CO-ORDINATES

DEPTH (METERS)	SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F	MISC. TESTS & REMARKS
	TOPSOIL				
	CLAY - brown - with silt - some sand and gravel				
1					
2	- little shale				
3	- shale and stones are damp to wet				
	End of hole @ 3.3 m.				

The UMA Group

PROJECT NEEPAWA HOG PROCESSING PLANT
CLIENT MANITOBA WATER SERVICES BOARD
JOB NUMBER 0326-049-01 DATE MAY 30, 1986

TEST HOLE 6
SHEET 6 of 8
CHECKED ______ DRAWN TH

TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △
10 20 30 40

SURFACE ELEVATION
CO-ORDINATES

DEPTH (METERS)	SOIL PROFILE	SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F	MISC. TESTS & REMARKS
		TOPSOIL				
		CLAY - brown - with silt - some sand and gravel				
1						
2						
3						
		End of hole @ 3.1 m.				

The UMA Group

PROJECT: NEEPAWA HOG PROCESSING PLANT
CLIENT: MANITOBA WATER SERVICES BOARD
JOB NUMBER: 0326-049-01   DATE: MAY 30, 1986

TEST HOLE: 7
SHEET 7 of 8
CHECKED ____ DRAWN TH

TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △
10 20 30 40

SURFACE ELEVATION ____
CO-ORDINATES

DEPTH (METERS)	SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F.	MISC. TESTS & REMARKS
	TOPSOIL				
	CLAY - brown - with silt - some sand and gravel				
	SILT - tan to yellow - damp to wet - little silt				
1	CLAY - brown - with silt - some sand and gravel				
2					
3					
	End of hole @ 3.1 m.				

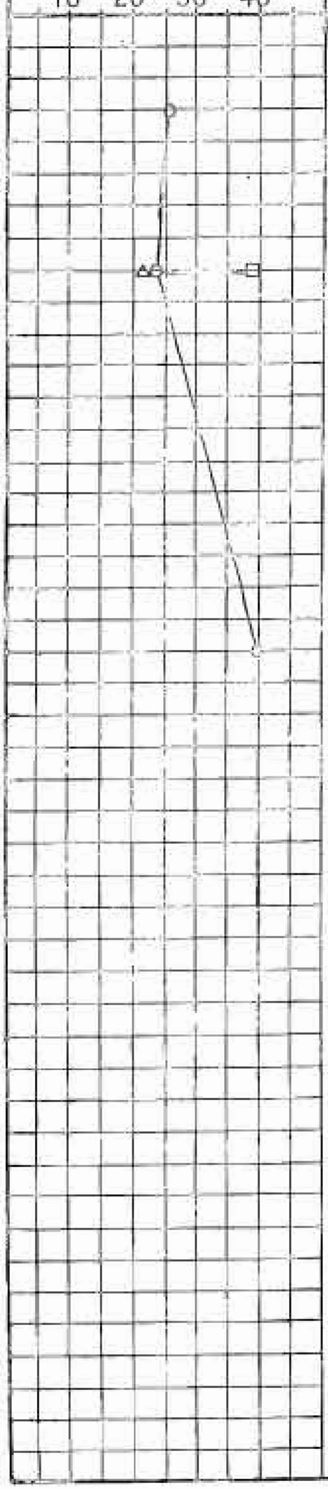
The UMA Group

PROJECT NEEPAWA HOG PROCESSING PLANT
CLIENT MANITOBA WATER SERVICES BOARD
JOB NUMBER 0326-049-01 DATE MAY 30, 1986

TEST HOLE 8
SHEET 8 of 8
CHECKED ______ DRAWN TH

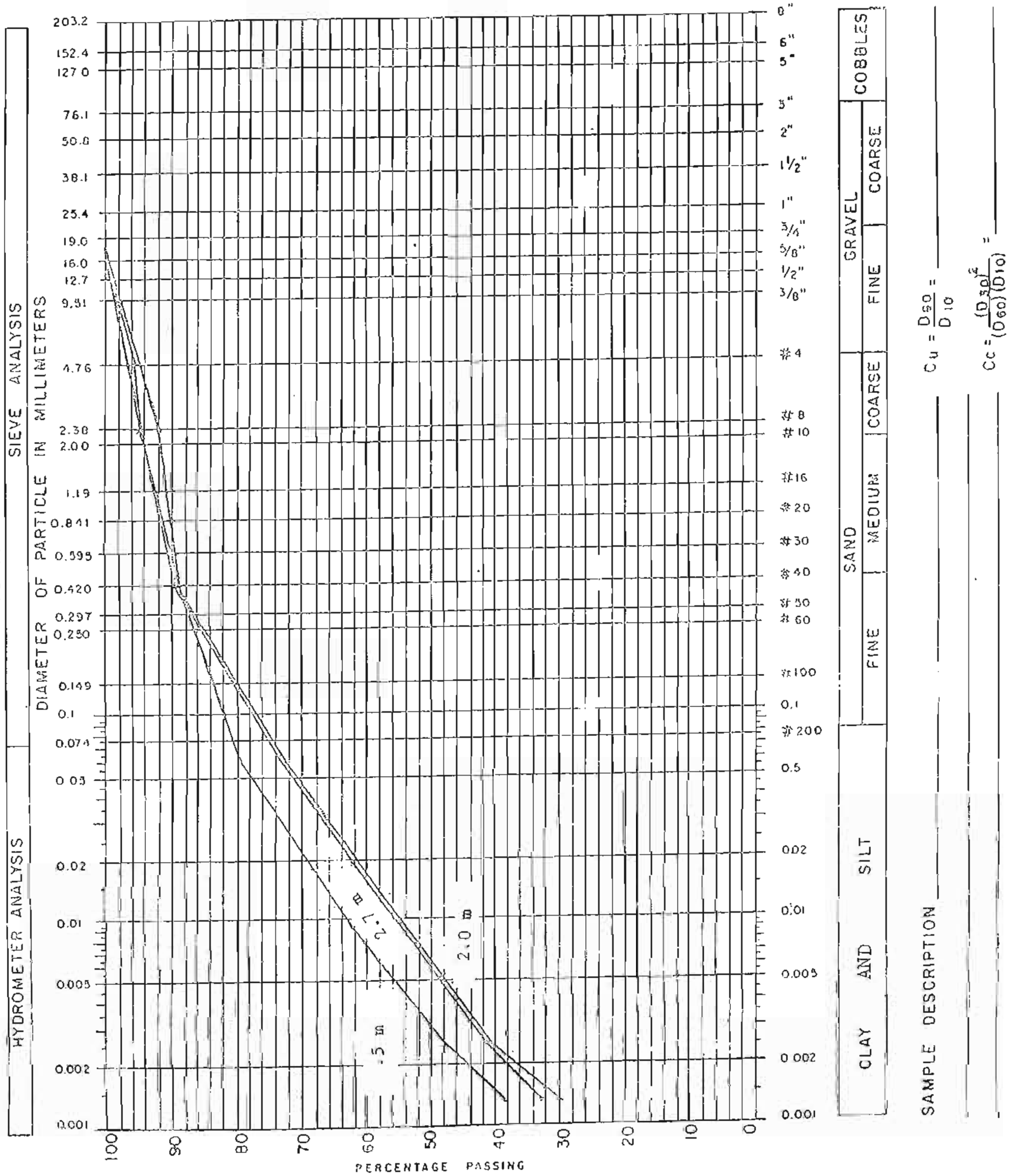
TEST HOLE LOG & SUMMARY OF LABORATORY TESTS

MOISTURE CONTENT - ○
LIQUID LIMIT - □
PLASTIC LIMIT - △
10 20 30 40



DEPTH (METERS)	SOIL PROFILE	SURFACE ELEVATION ______ / CO-ORDINATES / SOIL DESCRIPTION	SAMPLE No. & Type	STANDARD PENETRATION (BLOWS/FT.)	COMPRESSIVE STRENGTH P.S.F	MISC. TESTS & REMARKS
		CLAY - brown - with silt - some sand and gravel				
1						
		- becoming wetter				
2						
		End of hole @ 2.4 m.				
3						

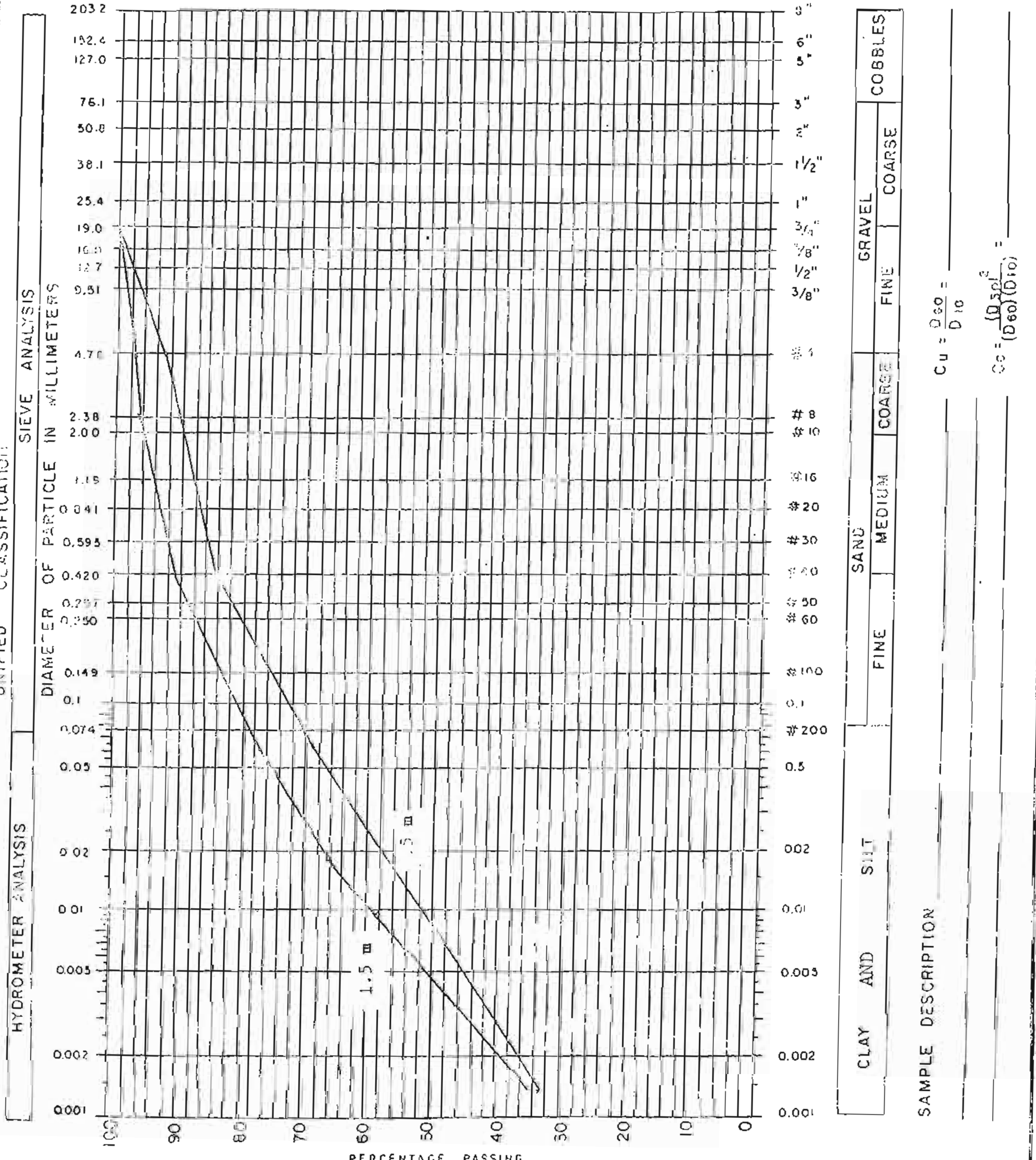
GRADATION ANALYSIS



UMA Engineering Ltd.
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

JOB NO. 0326-049-01	DATE: MAY 23, 1986
PROJECT NEEPAWA HOG PROCESSING PLANT	
SITE: A	
LOCATION: SEE DETAILED SITE INVESTIGATION C-2	
HOLE NO.: 1	SAMPLE NO.
DEPTH	TECHNICIAN T.H.

GRADATION ANALYSIS



$Cu = \frac{D_{60}}{D_{10}} =$

$Cc = \frac{(D_{30})^2}{(D_{60})(D_{10})} =$

UMA Engineering Ltd.
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

JOB NO: 0326-049-01 DATE: MAY 23, 1986
PROJECT: NEEPAWA HOG PROCESSING PLANT
SITE: A
LOCATION: SEE DETAILED SITE INVESTIGATION C-2
HOLE NO.: 5 SAMPLE NO.:
DEPTH: TECHNICIAN: T.H.

DYREGROV CONSULTANTS
Consulting Geotechnical Engineers

101 - 1555 ST JAMES STREET
WINNIPEG, MB R3H 1B5
TEL (204) 632-7252
FAX (204) 632-1442
dyregrov@mts.net

June 11, 2008

File #283051

Pharmer Engineering LLC
1998 West Judith Lane
Boise, Idaho 83705
U.S.A.

Attention: Mr. Dan Barbeau, P.E.

Dear Sir:

Re: Proposed Expansion
Springhill Farms
Industrial Wastewater Treatment Facility
Neepawa, Manitoba

We are forwarding 4 copies of our geotechnical report for the above-noted facility. If you have any questions or comments regarding the report, I would be pleased to discuss them with you.

Yours truly,

DYREGROV CONSULTANTS

Per:

A.O. Dyregrov, P.Eng.

Encl.

DYREGROV CONSULTANTS
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL INVESTIGATION

PROPOSED EXPANSION

SPRINGHILL FARMS

INDUSTRIAL WASTEWATER TREATMENT FACILITY

NEEPAWA, MANITOBA

Prepared for

PHARMER ENGINEERING

on behalf of

NEEPAWA, MANITOBA

June 2008

Project No. 283051

GEOTECHNICAL INVESTIGATION

PROPOSED EXPANSION

SPRINGHILL FARMS

INDUSTRIAL WASTEWATER TREATMENT FACILITY

NEEPAWA, MANITOBA

Prepared for

PHARMER ENGINEERING

on behalf of

NEEPAWA, MANITOBA

June 2008 **Project No. 283051**

1.0 INTRODUCTION

Dyregrov Consultants have undertaken a geotechnical investigation for the proposed Springhill Farms Industrial Wastewater Treatment Facility near Neepawa, Manitoba. The purpose of the investigation was to determine the soil conditions necessary for the design of the foundations of the various components of the project. This report contains all of our findings and includes recommendations for the design and construction of geotechnically related facilities. The work was undertaken at the instruction of Mr. Dan Barbeau, P.Eng. of Pharmer Engineering LLC on behalf of the Town of Neepawa by electronic mail of May 23, 2008.

2.0 SITE DESCRIPTION

The site of the Springhill Farms Plant is approximately 4 kilometres (2.5 miles) east of Neepawa, Manitoba on the north side of PTH 16. The location of the proposed Industrial Wastewater Treatment Facility is northwest of the Plant as illustrated on the attached Pharmer Engineering Drawing C1.0, Figure 1. The site is a relatively flat grassed area bordered on the east by a drainage swale. Mature trees are along the swale and a small bluff of trees is present northwest of the location of the proposed facilities.

3.0 PROPOSED DEVELOPMENT

The components of the proposed development are indicated on Figure 2.

4.0 SITE AND LABORATORY INVESTIGATIONS

On May 26, 2008, five test holes were drilled at the locations shown on Figure 2. The test drilling was undertaken by Paddock Drilling of Brandon, Manitoba using a track-mounted drill which turned 127 mm (5.0 inch) diameter augers. The test holes were carried to depths of 6.10 metres (20 feet). Disturbed samples were obtained from the auger cuttings for sample reclassification and moisture content determinations. In addition, Dynamic Cone Penetration Tests were performed at various locations and depths. This test is performed by using a 51 mm (2 inch) diameter steel cone, driven into the soil with a 63.5 kg (140 lb.) weight having a free fall of 760 mm (30 inches). The number of blows required to advance the cone a distance of 300 mm (12 inches) is recorded. This number provides an indication of the relative density of the soil which can be related empirically to the soil bearing capacity.

The results of the field and laboratory tests are included on the test hole logs, Figures 3 to 7.

5.0 THE SOIL PROFILE

The soil profiles at the locations of the five test holes were the same, namely a very fine uniformly grained sand deposit with little or no fines (silt and clay) in approximately the upper 2.0 metres (6.5 feet). The silt and clay fraction was less than 10 percent. The sand contained 40 to 60 percent silt and clay sizes below this depth. The grain size distributions of samples from various depths in Test Hole WWTP-1 and WWTP-3 are attached as Figures 8 and 9 respectively. The sand was wet to saturated at depths ranging from 1.8 to 2.4 metres (6.0 to 8.0 feet) which is probably related to the groundwater levels in the area. There was no accumulation of water in the test holes, except at Test Hole WWTP2 where 50 to 75 mm (2 to 3 inches) was recorded. Caving conditions occurred in all of the test holes with the extraction of the augers. The caving accumulations filled the borings to depths between 2.44 and 3.50 m (8.0 and 11.5 feet).

The dynamic cone penetration results above approximately the 2.0 metre (6.5 feet) depth were between 4 and 10 blows per 300 mm (12 inches) which is suggestive that it is in a loose state. Below this depth, the penetrations results in the silty sand were more than about 20 which suggests that it is in a compact state.

The foregoing stratigraphic conditions are similar to that reported for other existing facilities located in the area.

6.1 General

The facilities which are proposed to be provided for the development are illustrated on Figure 2.

The pre-engineered buildings are anticipated to be supported on spread footings with slab-on-grade floors. The facilities placed within these structures will be supported on the floors.

The large diameter external tanks will be supported on individual concrete surface foundations which may have a concrete ring wall footing. These tanks have large diameters, up to 28 metres (81 feet).

In the largest pre-engineered building, A, Figure 2, will be two, 9.0 metre (30 feet) long concrete membrane tanks which will have water depths of about 3.0 metres (10 feet). They will be supported directly on the concrete slab-on-grade.

In the other pre-engineered building, B, will be two DAF tanks and several 3.0 metre (10 foot) diameter plastic tanks. Water depths in these facilities will be in the order of 3.0 metres (10 feet). This building will contain a below grade sump which will have a footprint of approximately 2.5 metres (8.0 feet) by 4.5 metres (15 feet) and a depth of about 2.5 metres (8.0 feet).

6.2 Foundations

The preferred support for the various facilities is footings placed near the existing ground surface. For small footings, such as expected to support the pre-engineered building, their major impact would be on the loose very fine grained sand that is present to a depth of about 2.0 metres (6.5 feet). For these small and shallow footings, the design bearing pressures should be limited to 100 kPa (2000 psf). If the footings were based in the compact sand near the 2.0 metre (6.5 foot) depth, a design bearing pressure of 200 kPa could be used. Under the foregoing conditions, settlements of the footings would be expected to be less than 25 mm (1.0 inch). Minimum width of footings should not be less than 1.20 metres (4.0 feet).

It is recommended that a minimum of 300 mm (12 inches) of crushed granular base course be placed beneath the footings to be located on the upper very fine sand. The crushed granular base course should extend 300 mm (12 inches) outside of the footprint of the footings. It should be compacted to at least a density of 98 percent of Standard Proctor Density at optimum water content. The intent of the foregoing is to confine the very fine sand in its natural condition during construction.

For the footings to be placed below the very fine sand at a depth of about 2 metres (6.5 feet), the use of the crushed granular base course is not required. The excavation of the finished bearing surface at this depth should be undertaken manually to remove any disturbed and loose materials.

It should be noted that the excavations for these deeper footings will require flat slopes due to the loose and dry condition of the very fine sand. Slopes of 2 horizontal to 1 vertical or flatter may be required to keep the cut slopes from ravelling.

The excavation for the below grade sump will extend to a depth of 4.5 metres (15 feet). The foregoing slopes will be required and potential impacts of groundwater problems will have to be reviewed. It is anticipated that the groundwater level could be controlled during construction by dewatering wells. The alternative to excavation is closed shoring. The selection of construction should be left to the contractor as well as the design of the shoring system.

The backfill of all excavations can be undertaken using excavated materials. These materials should be compacted to 100 percent of Standard Proctor Maximum Dry Density at optimum moisture content to minimize potential differential settlements between backfilled and undisturbed areas.

The silty sand below the depth of about 2 metres (6.5 feet) is potentially frost susceptible. Consideration of frost protection for the footings should be considered. This consideration can be assessed during the preliminary design phase.

Where the slab-on-grade floor loadings are in excess of the recommended design bearing pressures, individual footings may be used which would reduce the loads by increasing the size of the bearing areas.

The foundations for the individual large diameter tanks may be sized on the basis of 100 kPa (2000 psf). This will require that some of the individual foundations will have to be increased beyond the size of the tank diameter. Where a ring foundation is considered, it could be supported at a depth of about 2.0 metres (6.5 feet) where bearing pressures of 200 kPa (4000 psf) could be used.

Other types of foundations could include driven timber piles and dynamically cast-in-place concrete piles, i.e., Compacto or Franki. The viability and load carrying capacities for each of these piles should be assessed during the preliminary design phase.

6.3 Floor Slabs

The use of slabs-on-grade are acceptable for the development. It is recommended that the subgrade preparation should include the removal of all organic surficial materials and compaction of the subgrade to a uniform density of 95 percent of Standard Proctor Density at optimum moisture content. It is also recommended that the subgrade be covered with at least 150 mm (6 inches) of crushed granular base course for protection of the compacted subgrade and for improved trafficability in the work areas. Additional thicknesses required for site grading should be with the same materials.

6.4 Below Grade Walls

Below grade walls, such as the sump pit, which are backfilled with the excavated sand should be designed to resist lateral earth pressures that are derived on the basis of the following conventional relationship which produces a triangular pressure distribution:

$$P = K \gamma D$$

where P = lateral earth pressure at depth D (kPa) [psf]
K = lateral earth pressure coefficient (0.35)
γ = soil and backfill unit weight (22.0 kN/m^3) [137 pcf]
D = depth from finished grade to point of pressure calculation (m) [ft.]

These pressures should be increased by the hydrostatic pressure induced by a groundwater level assumed to be at a depth of 2.0 metres (6.5 feet).

6.5 Pavements

If pavements are to be provided, the pavement structure should consist of at least 75 mm of asphaltic concrete on 380 mm of crushed granular base course. If the asphaltic concrete is not provided, the crushed granular base course should be increased to 490 mm. For parking areas, the pavement structure should consist of 50 mm of asphaltic concrete on 200 mm of crushed granular base course or 275 mm of crushed granular base course.

These pavement structures should be placed on a prepared subgrade as previously described in Section 6.3.

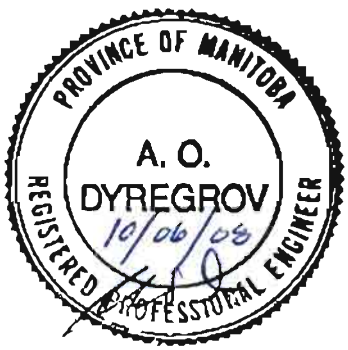
6.6 Other

Concrete in contact with the soil should be manufactured with Normal Portland Cement and should be of high quality.

Surface gradients should be away from the structure at gradients of 2 percent.

Respectfully submitted,

DYREGROV CONSULTANTS



Per:

A.O. Dyregrov, P.Eng.

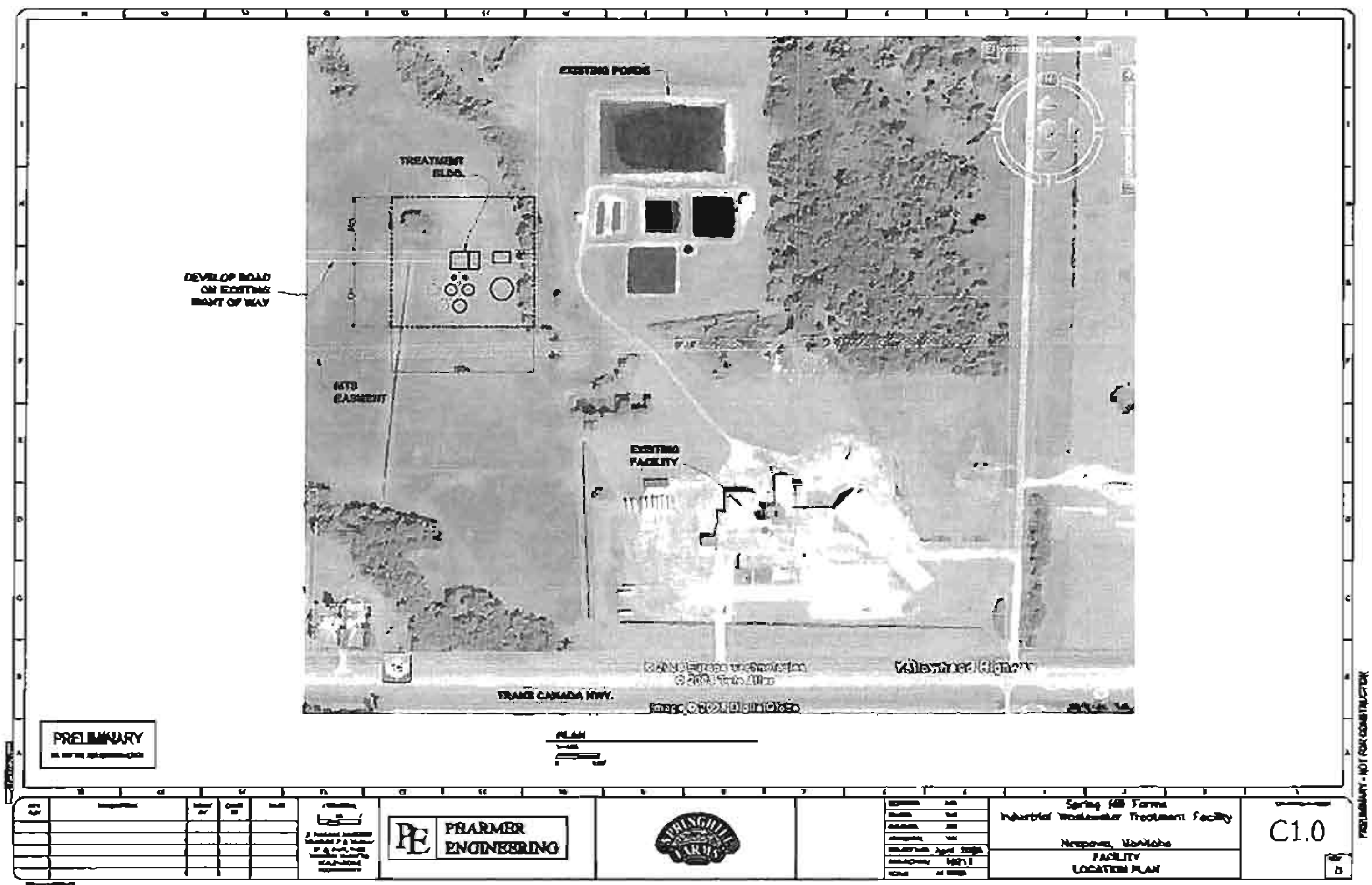

EXISTING PONDS
TREATMENT BLDG.
DEVELOP ROAD ON EXISTING RIGHT OF WAY
MTS EASMENT
EXISTING FACILITY
TRANS CANADA HWY.
PRELIMINARY
PLAN
PEARMER ENGINEERING
SPRINGHILL FARMS
Spring Hill Farms
Industrial Wastewater Treatment Facility
Neepawa, Manitoba
FACILITY
LOCATION PLAN
C1.0
PRELIMINARY - NOT FOR CONSTRUCTION

FIGURE 1

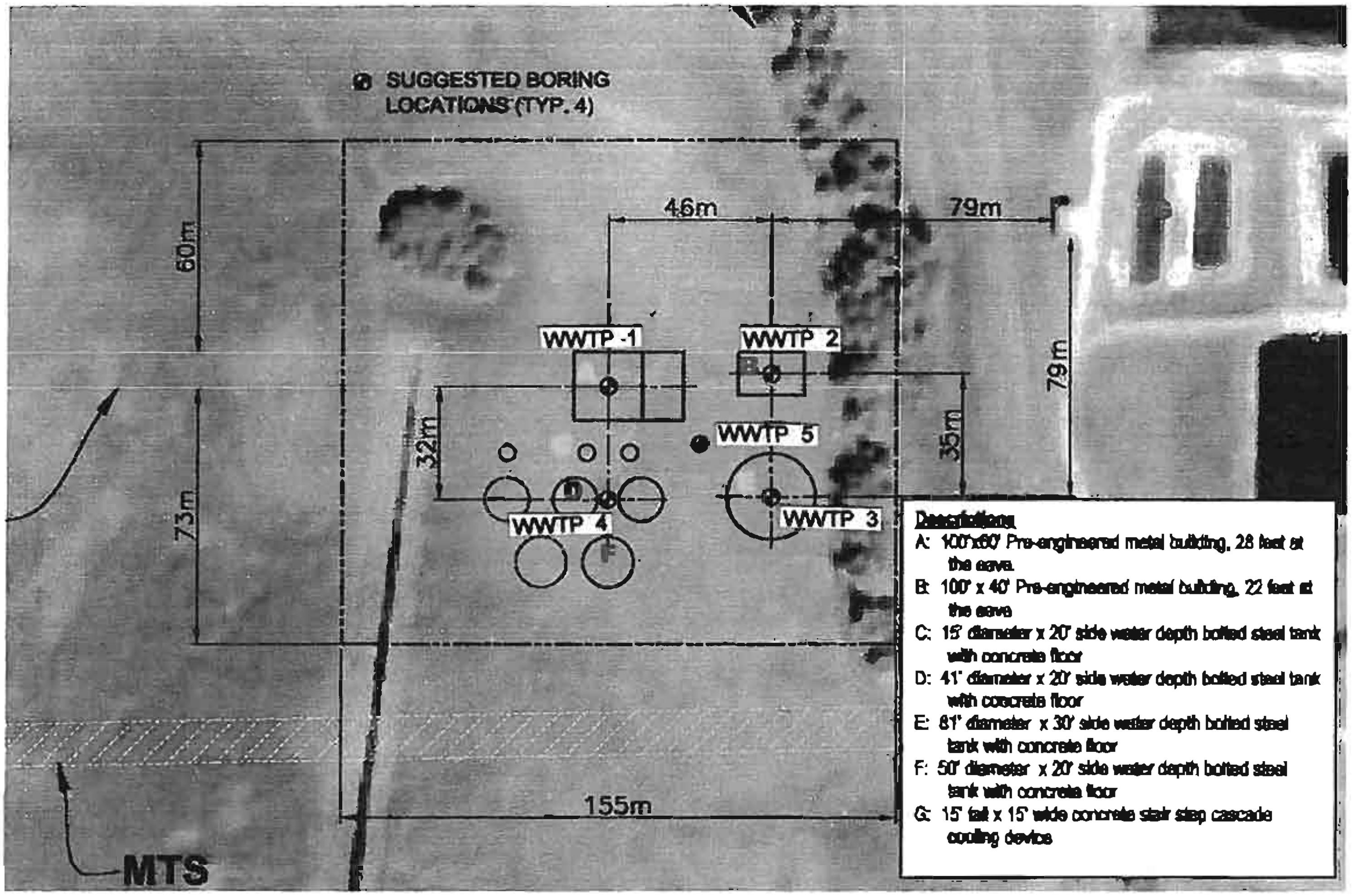

SUGGESTED BORING LOCATIONS (TYP. 4)
60m
73m
46m
79m
79m
32m
35m
155m
WWTP -1
WWTP 2
WWTP 5
WWTP 4
WWTP 3
MTS
Descriptions
A: 100'x60' Pre-engineered metal building, 28 feet at the eave.
B: 100' x 40' Pre-engineered metal building, 22 feet at the eave
C: 15' diameter x 20' side water depth bolted steel tank with concrete floor
D: 41' diameter x 20' side water depth bolted steel tank with concrete floor
E: 81' diameter x 30' side water depth bolted steel tank with concrete floor
F: 50' diameter x 20' side water depth bolted steel tank with concrete floor
G: 15' tall x 15' wide concrete stair step cascade cooling device

FIGURE 2

DYREGROV CONSULTANTS	Logged/Dwn.: SG/TJH Checked: AOD	Test Hole No. WWTP1	Project No. 283051
PROJECT: WWTP @ Springhill Plant CLIENT: Town of Neepawa		DATE OF INVEST : May 28, 2008 DRILL : Paddock, 125 mm Auger	

DEPTH (FT)	DEPTH (M)	ELEV. (M)	SYM	SOIL DESCRIPTION (DEPTHS IN M)
0.00	0.00	100.00		0.00-6.10 SAND LIGHT BROWN, FINE, DAMP TO MOIST CLEAN
0.82	0.25	99.75		
1.64	0.50	99.50		
2.46	0.75	99.25		
3.28	1.00	99.00		
4.10	1.25	98.75		
4.92	1.50	98.50		
5.74	1.75	98.25		WET TO SATURATED BELOW 1.8
6.56	2.00	98.00		
7.38	2.25	97.75		
8.20	2.50	97.50		
9.02	2.75	97.25		
9.84	3.00	97.00		
10.66	3.25	96.75		DARK GREY, SILTY, AT 3.35
11.48	3.50	96.50		
12.30	3.75	96.25		
13.12	4.00	96.00		
13.94	4.25	95.75		
14.76	4.50	95.50		
15.58	4.75	95.25		
16.40	5.00	95.00		
17.22	5.25	94.75		
18.04	5.50	94.50		
18.86	5.75	94.25		
19.68	6.00	94.00		
20.50	6.25	93.75		END OF TEST HOLE AT 6.10 IN DARK GREY SAND
21.32	6.50	93.50		

NOTE:
- TEST HOLE OPEN TO 2.44
- NO WATER IN TEST HOLE AT COMPLETION OF DRILLING

MOISTURE CONTENT (%)

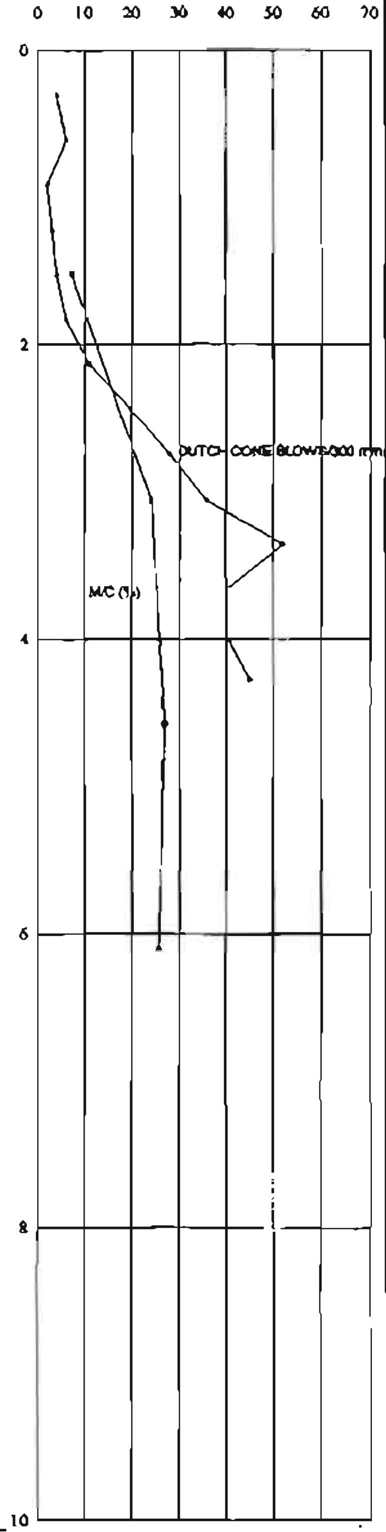


FIGURE 3

DYREGROV CONSULTANTS	Logged/Dwn.: SG/TJH Checked: AOO	Test Hole No. WWTP2	Project No. 283051
PROJECT: WWTP @ Springhill Plant CLIENT: Town of Neepawa		DATE OF INVEST : May 26, 2008 DRILL : Paddock, 125 mm Auger	

DEPTH (FT)	DEPTH (M)	ELEV. (M)	SYM	SOIL DESCRIPTION (DEPTHS IN M)
0.00	0.00	100.00		0.00-6.10 SAND DARK BROWN, SILTY TO 0.15 LIGHT BROWN, FINE, CLEAN DAMP TO WET
0.82	0.25	99.75		
1.64	0.50	99.50		
2.46	0.75	99.25		
3.28	1.00	99.00		
4.10	1.25	98.75		
4.92	1.50	98.50		
5.74	1.75	98.25		SATURATED AT 1.8
6.56	2.00	98.00		
7.38	2.25	97.75		
8.20	2.50	97.50		
9.02	2.75	97.25		
9.84	3.00	97.00		
10.66	3.25	96.75		
11.48	3.50	96.50		SILTY AT 3.7
12.30	3.75	96.25		DARK GEY AT 3.96
13.12	4.00	96.00		
13.94	4.25	95.75		
14.76	4.50	95.50		
15.58	4.75	95.25		CLEANER BELOW 4.67
16.40	5.00	95.00		
17.22	5.25	94.75		
18.04	5.50	94.50		
18.86	5.75	94.25		
19.68	6.00	94.00		
20.50	6.25	93.75		END OF TEST HOLE AT 6.10 IN DARK GREY SAND
21.32	6.50	93.50		NOTE: TEST HOLE OPEN TO 3.05 SLIGHT SEEPAGE , 50.75 mm WATER IN TEST HOLE

MOISTURE CONTENT (%)

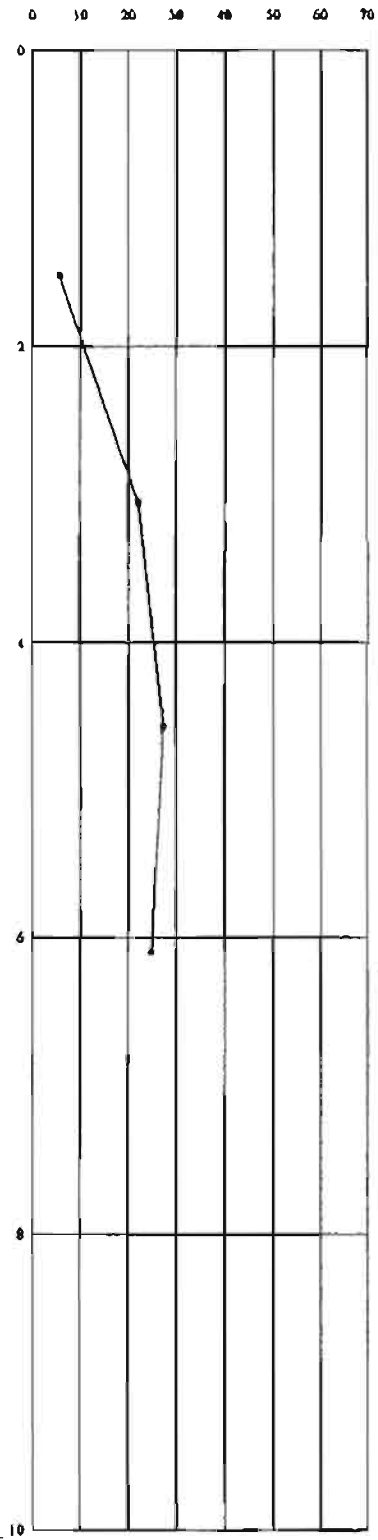


FIGURE 4

DYREGROV CONSULTANTS	Logged/Dwn.: SG/TJH Checked: AOD	Test Hole No. WWTP3	Project No. 283051
PROJECT: WWTP @ Springhill Plant CLIENT: Town of Neepawa		DATE OF INVEST : May 28, 2008 DRILL : Paddock, 125 mm Auger	

DEPTH (FT)	DEPTH (M)	ELEV. (M)	SYM	SOIL DESCRIPTION (DEPTHS IN M)
0.00	0.00	100.00		0.00-6.10 SAND LIGHT BROWN, FINE CLEAN, MOIST
0.82	0.25	99.75		
1.64	0.50	99.50		
2.46	0.75	99.25		
3.28	1.00	99.00		
4.10	1.25	98.75		
4.92	1.50	98.50		
5.74	1.75	98.25		
6.56	2.00	98.00		
7.38	2.25	97.75		SILTY AT 2.44 TO 3.66 WET TO SATURATED AT 2.4
8.20	2.50	97.50		
9.02	2.75	97.25		
9.84	3.00	97.00		
10.66	3.25	96.75		
11.48	3.50	96.50		
12.30	3.75	96.25		
13.12	4.00	96.00		
13.94	4.25	95.75		
14.76	4.50	95.50		
15.58	4.75	95.25		GREY AT 4.88
16.40	5.00	95.00		
17.22	5.25	94.75		
18.04	5.50	94.50		
18.86	5.75	94.25		
19.68	6.00	94.00		
20.50	6.25	93.75		END OF TEST HOLE AT 6.10 IN GREY SAND
21.32	6.50	93.50		NOTE: -TEST HOLE OPEN TO 3.20

MOISTURE CONTENT (%)

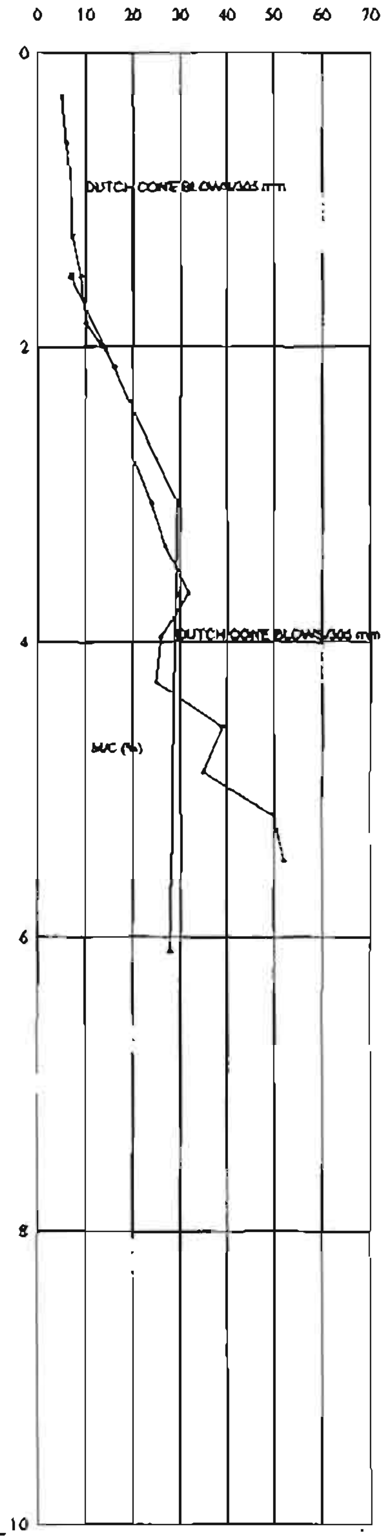


FIGURE 6

DYREGROV CONSULTANTS	Logged/Dwn.: SG/TJH Checked: AOD	Test Hole No. WWTP4	Project No. 283051
PROJECT: WWTP @ Springhill Plant CLIENT: Town of Neepawa		DATE OF INVEST.: May 26, 2008 DRILL: Paddock, 125 mm Auger	

DEPTH (FT)	DEPTH (M)	ELEV. (M)	SYM	SOIL DESCRIPTION (DEPTHS IN M)
0.00	0.00	100.00		
0.82	0.25	99.75		0.00-6.10 SAND DARK BROWN TO 0.15 LIGHT BROWN, FINE, CLEAN DAMP TO MOIST
1.64	0.50	99.50		
2.46	0.75	99.25		
3.28	1.00	99.00		
4.10	1.25	98.75		
4.92	1.50	98.50		
5.74	1.75	98.25		
6.56	2.00	98.00		
7.38	2.25	97.75		WET TO SATURATED BELOW 2.1 SILTY, DARK BROWN
8.20	2.50	97.50		
9.02	2.75	97.25		
9.84	3.00	97.00		
10.66	3.25	96.75		
11.48	3.50	96.50		
12.30	3.75	96.25		
13.12	4.00	96.00		
13.94	4.25	95.75		
14.76	4.50	95.50		
15.58	4.75	95.25		GREY AT 4.87
16.40	5.00	95.00		
17.22	5.25	94.75		
18.04	5.50	94.50		
18.86	5.75	94.25		
19.68	6.00	94.00		
20.50	6.25	93.75		END OF TEST HOLE AT 6.10 IN GREY SAND
21.32	6.50	93.50		NOTE: -TEST HOLE OPEN TO 3.50 AT COMPLETION OF DRILLING

MOISTURE CONTENT (%)

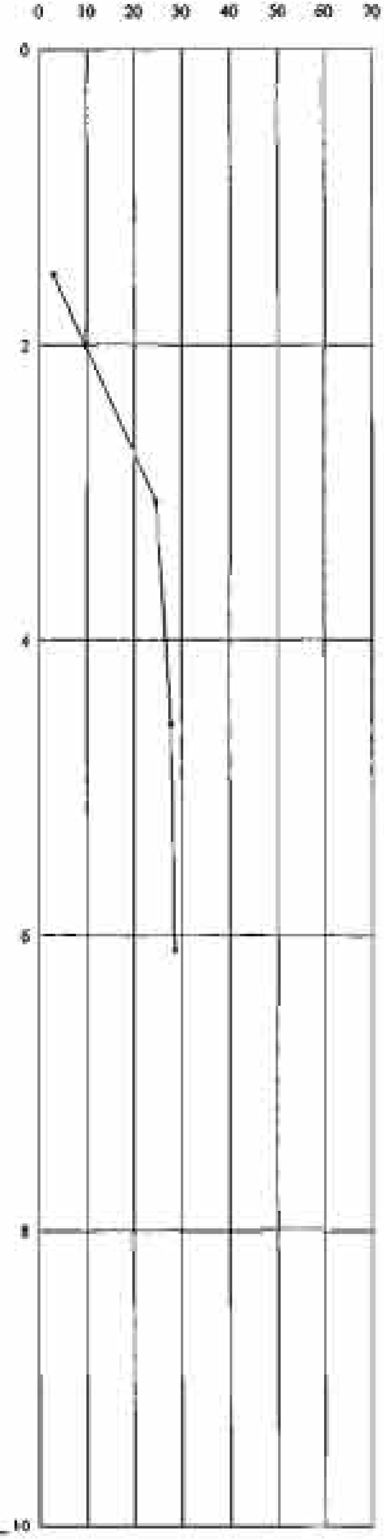


FIGURE 6

DYREGROV CONSULTANTS	Logged/Dwn.: SG/TJH Checked: AOD	Test Hole No. WWTP5	Project No. 283051
PROJECT: WWTP @ Springhill Plant CLIENT: Town of Neepawa		DATE OF INVEST : May 26, 2008 DRILL : Paddock, 125 mm Auger	

DEPTH (FT)	DEPTH (M)	ELEV. (M)	SOIL DESCRIPTION (DEPTHS IN M)
0.00	0.00	100.00	0.00-6.10 SAND DARK BROWN TO 0.15 LIGHT BROWN, FINE, CLEAN TO 2.1
0.82	0.25	99.75	
1.64	0.50	99.50	
2.46	0.75	99.25	
3.28	1.00	99.00	
4.10	1.25	98.75	
4.92	1.50	98.50	
5.74	1.75	98.25	
6.56	2.00	98.00	
7.38	2.25	97.75	SILTY AT 2.1 WET TO SATURATED BELOW 2.1
8.20	2.50	97.50	
9.02	2.75	97.25	
9.84	3.00	97.00	
10.66	3.25	96.75	
11.48	3.50	96.50	
12.30	3.75	96.25	
13.12	4.00	96.00	
13.94	4.25	95.75	GREY AT 4.27
14.76	4.50	95.50	
15.58	4.75	95.25	
16.40	5.00	95.00	
17.22	5.25	94.75	
18.04	5.50	94.50	
18.86	5.75	94.25	
19.68	6.00	94.00	
20.50	6.25	93.75	END OF TEST HOLE AT 6.10 IN GREY SAND
21.32	6.50	93.50	NOTE: TEST HOLE OPEN TO 3.35 AT COMPLETION OF DRILLING

MOISTURE CONTENT (%)

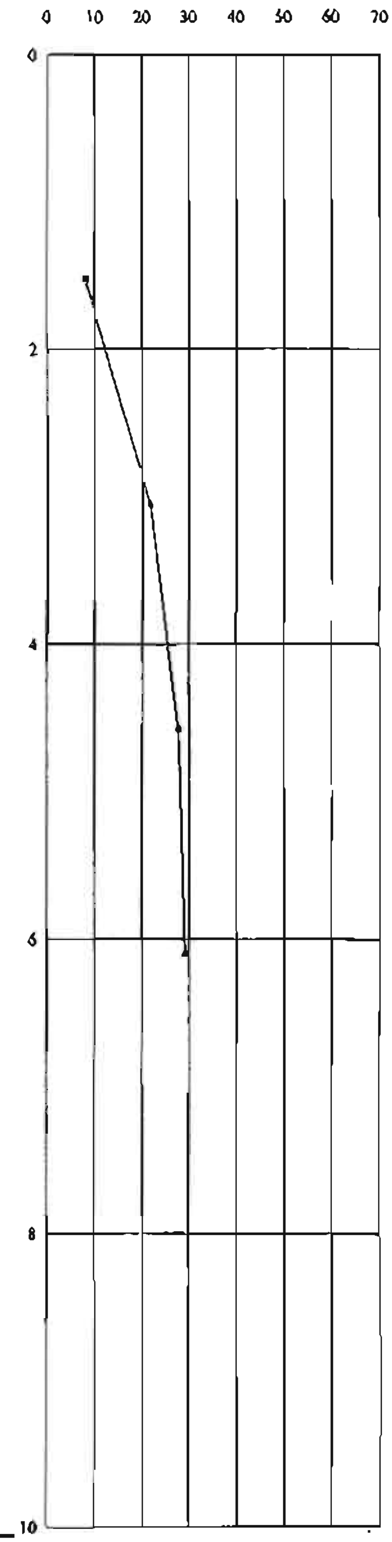
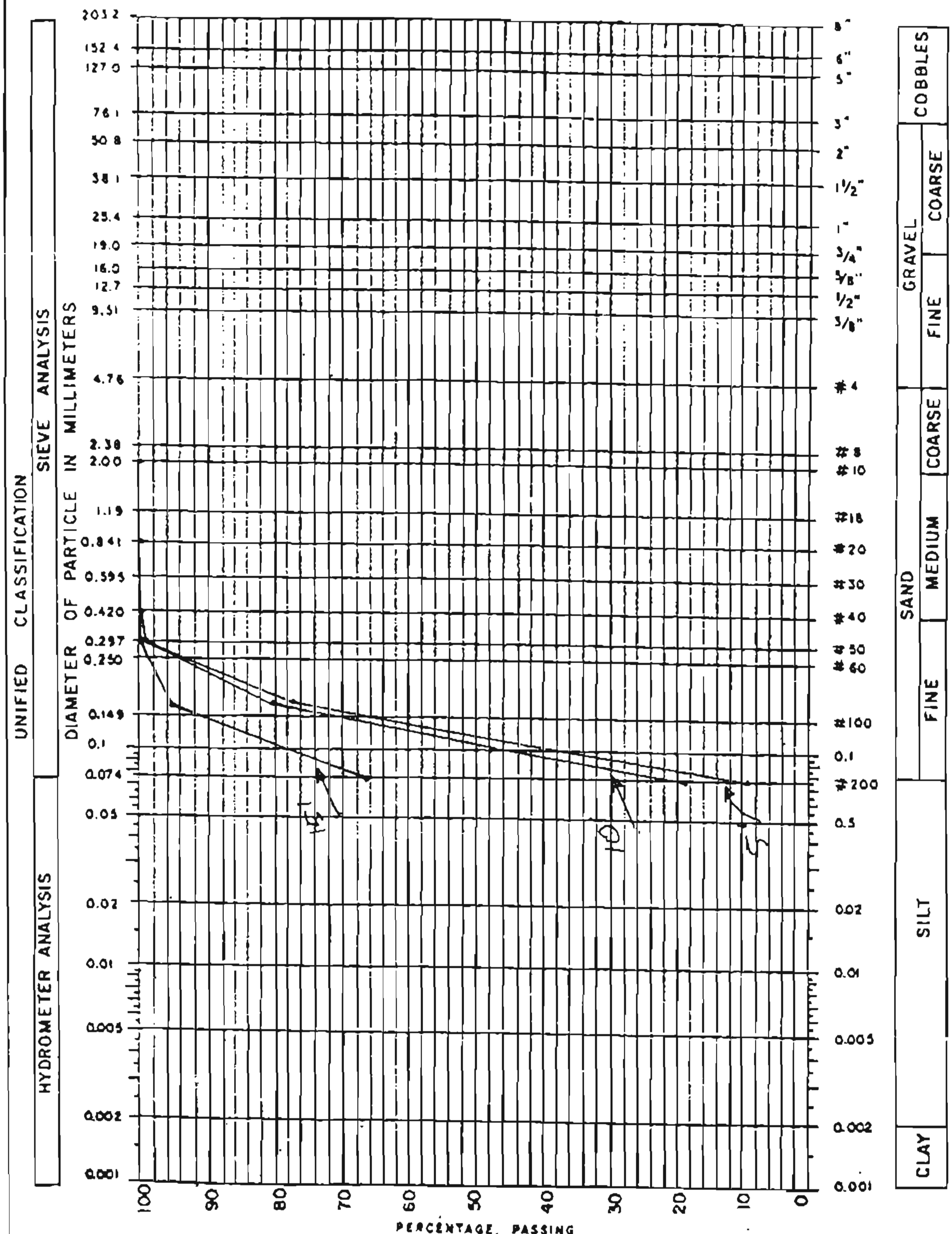


FIGURE 7

GRADATION ANALYSIS



$C_u = \frac{D_{60}}{D_{10}} =$

$C_c = \frac{(D_{30})^2}{(D_{60})(D_{10})} =$

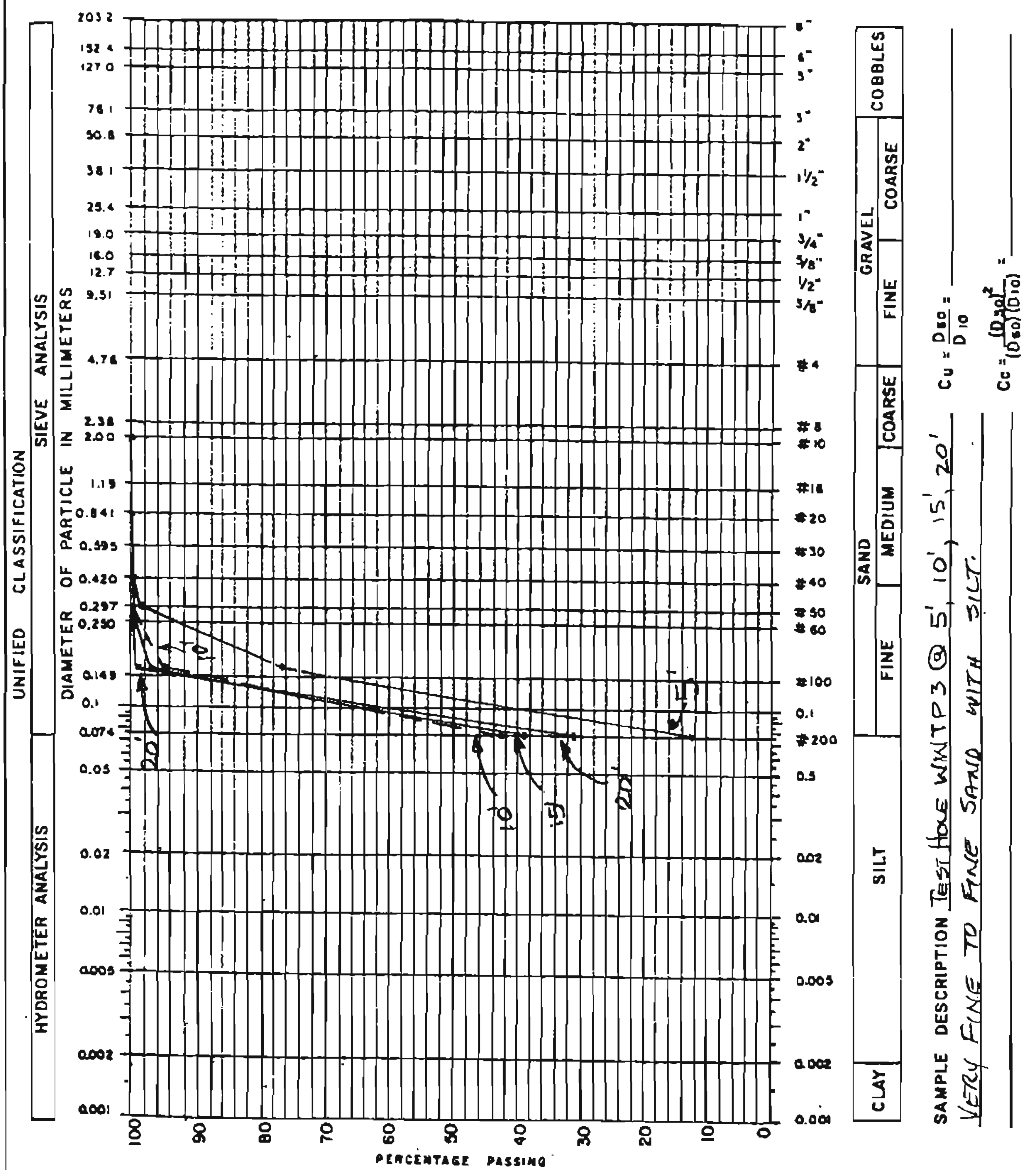
SAMPLE DESCRIPTION *TEST HOLE WWTP1 @ 5' 10' 15'*
VERY FINE TO FINE SAND WITH SILT

DYREGROV CONSULTANTS
CONSULTING GEOTECHNICAL ENGINEERS

JOB NO.: *283051* DATE: *JUNE 9/08*
PROJECT: *WASTE WATER TREATMENT PLANT*
SITE: *NEEPAWA*
LOCATION:
HOLE NO.: SAMPLE NO.:
DEPTH: TECHNICIAN:

FIGURE 8

GRADATION ANALYSIS



$C_u = \frac{D_{60}}{D_{10}} =$

$C_c = \frac{(D_{30})^2}{(D_{60})(D_{10})} =$

DYREGROV CONSULTANTS

CONSULTING GEOTECHNICAL ENGINEERS

JOB NO.: 283051 DATE: JUNE 9/08

PROJECT: WASTE WATER TREATMENT PLANT

SITE: NEEPAWA

LOCATION:

HOLE NO.: SAMPLE NO.:

DEPTH: TECHNICIAN: TH

FIGURE 9